Watershed Assessment of Portions of the Lower Musselshell and Fork Peck Reservoir Subbasins

Prepared for:

Bureau of Land Management,
Lewistown Field Office

By:

Linda K. Vance and David M. Stagliano

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Executive Summary

To assist the BLM in resource planning, we conducted a multi-scale ecological assessment of nine watersheds in the Fort Peck Reservoir and Lower Musselshell River sub-basins northeast of Lewistown, Montana. The area occupied by the watersheds is diverse, ranging from Douglas fir and lodgepole pine forests to rolling grasslands to the sharply dissected, Pondreosa pine and juniper covered breaks around the Missouri and Musselshell rivers. The goal of the study was to provide both landscape-level assessments of watershed health and integrity as well as site-specific evaluations of lentic wetlands and aquatic condition within the 970,000 acre study area. This was accomplished using both broad-scale GIS analysis and field sampling.

Our broad-scale GIS assessment examined underlying biological diversity, measured current conditions, and evaluated potential threats. Several key findings emerged from this analysis:

• The Armells Creek watershed is the most hydrologically and topographically complex of the nine watersheds, and natural land cover (forests, grasslands, shrublands and woody wetlands) is highest in the Drag Creek watershed.
• The Sacajawea (Crooked Creek) watershed has the least natural land cover in its riparian corridors, indicating significant riparian vegetation loss since presettlement times;
• The Blood Creek watershed has the highest road density, and the highest number of roads crossing streams.
• The Drag Creek watershed, which includes parts of the Musselshell River valley, has the highest observed levels of noxious weeds, with both leafy spurge and spotted knapweed present.
• Across all watersheds, grazing is the dominant land use; approximately 90% of the land is grazed, regardless of ownership type (private or public).
• Perennial streams, rivers and wetlands are uncommon. Most streams are intermittent or ephemeral, and most wetlands occur on the fringes or overflow areas of manmade ponds and reservoirs.

Fine-scale rapid assessments focused on wetlands, ponds, springs and streams. We conducted assessments of Proper Functioning Condition at 43 sites and detailed aquatic surveys at seven lotic, seven lentic, and one mountain spring site. From those assessments and surveys, we found:

• Of the 43 wetlands assessed, seven were found to be in proper functioning condition, seven were not functioning, and the remainder were functioning at risk. Most (20) of the wetlands that were functioning at risk were stable; three exhibited an upward trend and four exhibited a downward trend.
• Sixteen of these wetlands were on land owned or managed by the BLM. Of these, one was in proper functioning condition, three were not functioning, two were functioning with a downward trend, and the remainder are functioning at risk but stable. With continued management, the trend on the stable wetlands should be upward. Given the percentage of BLM ownership in the study area, these proportions suggest that BLM-managed wetlands are in no better or worse condition than other wetlands.
• In our aquatic surveys, the highest site habitat scores were measured in the Sacajawea River watershed.
• With fish-based metrics, one lotic site ranked non-impaired, two were slightly impaired, one was moderately impaired, and two -- where fish were expected but not found -- were ranked severely impaired.
• With macroinvertebrate-based metrics, two of the lotic sites were non-impaired, four were slightly impaired, and one was severely impaired.

We also identified several management opportunities to support wetland and watershed health:

• Although leafy spurge, spotted knapweed, Russian knapweed, and salt cedar are found in the study area, they are not yet widespread, so vigilant monitoring and control may still prevent their incursion into weed-free areas;
• Many permittees already follow good grazing management practices to protect wetland and

riparian resources. Encouraging these practices, coupled with frequent utilization monitoring and the use of physical barriers where necessary, will help ensure the maintenance of wetland and riparian resources. Increased emphasis on habitat and recreation values in reservoir management could also improve wetland functions.

- The Woodhawk Creek watershed contains a wilderness study area, and continued management for maintenance of natural habitats will preserve or improve the watershed's condition. The Drag Creek watershed also has good potential to be managed for maintenance of natural habitat values.
- Oil and gas activities, even in surrounding watersheds, may impact the study area in the coming years. Proactive efforts to anticipate and plan for both direct (exploration and drilling) and indirect impacts (residential and recreational development) will reduce future risks to wetland and riparian resources.

Acknowledgements

We would like to thank the Montana State Office of the Bureau of Land Management (BLM), especially Mike Philbin, for funding assistance for the overall watershed assessment. Our work benefited from the field assistance of Karen Walker and Coburn Currier of the Montana Natural Heritage Program (MTNHP). We would also like to thank Tom Schemm and Jane Horton of MTNHP for their GIS support, and Coburn Currier for report formatting and publication. Greg Kudray and Sue Crispin of MTNHP provided helpful suggestions and editing comments, but any errors or omissions are our responsibility alone.

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Introduction

The nine study area watersheds (Figure 1) occupy just under one million acres in Petroleum, Fergus, Blaine, Phillips, and Garfield Counties in Central Montana. The watersheds are primarily within the Northwestern Great Plains Ecoregion (Woods et al. 1999), an unglaciated, semi-arid, rolling plain underlain by siltstone, shale, and sandstone and punctuated by occasional buttes. Native grasslands or dryland grains and pasture dominate the dissected topography, with cottonwood, willow, and box elder in riparian areas and ponderosa pine and juniper throughout the breaks. Portions of the southwestern and northeastern parts of the study area (the Judith Mountains and Little Rocky Mountains, respectively) lie within the Middle Rockies Ecoregion, characterized by Douglas fir, subalpine fir, and Engelmann spruce forests in the wetter sections, and lodgepole pine in the drier parts of the Judith Mountains. Northeast of the Missouri River is a small section of the Northwestern Glaciated Plains Ecoregion, where gently rolling, pine-studded glacial till plains overly marine shales. These Level III Ecoregions contain six Level IV Ecoregions, shown in Figure2.

The Missouri River crosses the study area in the Woodhawk-Bull Creek watershed. The Two Calf Creek, Armells Creek and Dry Armells Creek watersheds drain directly into the Missouri above Fort Peck Reservoir; Sacajawea River (a.k.a. Crooked Creek), Blood Creek, Drag Creek and Dovetail Creek drain into the lower Musselshell River, which joins the Missouri at the upstream end of Fort Peck Reservoir. According to cadastral records, the Bureau of Land Management (BLM) owns or administers close to 340,000 acres within the study area boundaries. BLM land, like other public land in the region, is primarily leased for grazing.

The goal of this study was to provide both landscape-level assessments of watershed health and integrity and site-specific evaluations of lentic wetlands and aquatic resources. This was accomplished using both field sampling and broad-scale GIS analysis. To provide a basis for comparison, the study area was analyzed by 5th code HUC and by Level IV Ecoregion. We used indices of watershed integrity developed in earlier watershed assessments (Crowe and Kudray 2003, Vance 2005, Vance et al. 2006) to provide a comprehensive GIS-based evaluation of landscape condition and health across the study area. Field sampling of terrestrial and aquatic sites provided detailed information on the composition and distribution of plant, invertebrate, and fish communities.

The Ecological Setting: Climate, Geology, Landform, Soils, and Hydrology

Climate

Within the study area watersheds, the climate is marked by cold winters, warm to hot summers, abundant sunshine, and winds from the west. Average annual precipitation ranges from 13 inches in the easternmost part of the study area to 15 inches in the westernmost parts, with small bands of high annual precipitation (19 to 22 inches) occurring in parts of the Judith and Little Rocky Mountains. Snow falls across the area between November and April, with annual totals ranging from less than 20 inches to more than 40. Rainfall is typically concentrated between April and June, although localized, intense thunderstorms occur frequently from July to September, often igniting wildfires in the Missouri Breaks area. Humidity is characteristically low, so soil moisture is lost rapidly during periods of high temperature and wind. Average low January temperatures are between 3º F and 15º F, while average high July and August temperatures are between 83º F and 88º F (Western Regional Climate Center 2007). The growing season is between 105 and 130 days (National Agricultural Statistics Service, 2007).

Geology, landform, and soils

The characteristic geology of the study area dates from the Cretaceous period, between 90 and 70 million years ago, when central Montana was covered by the Western Interior Seaway. Multiple

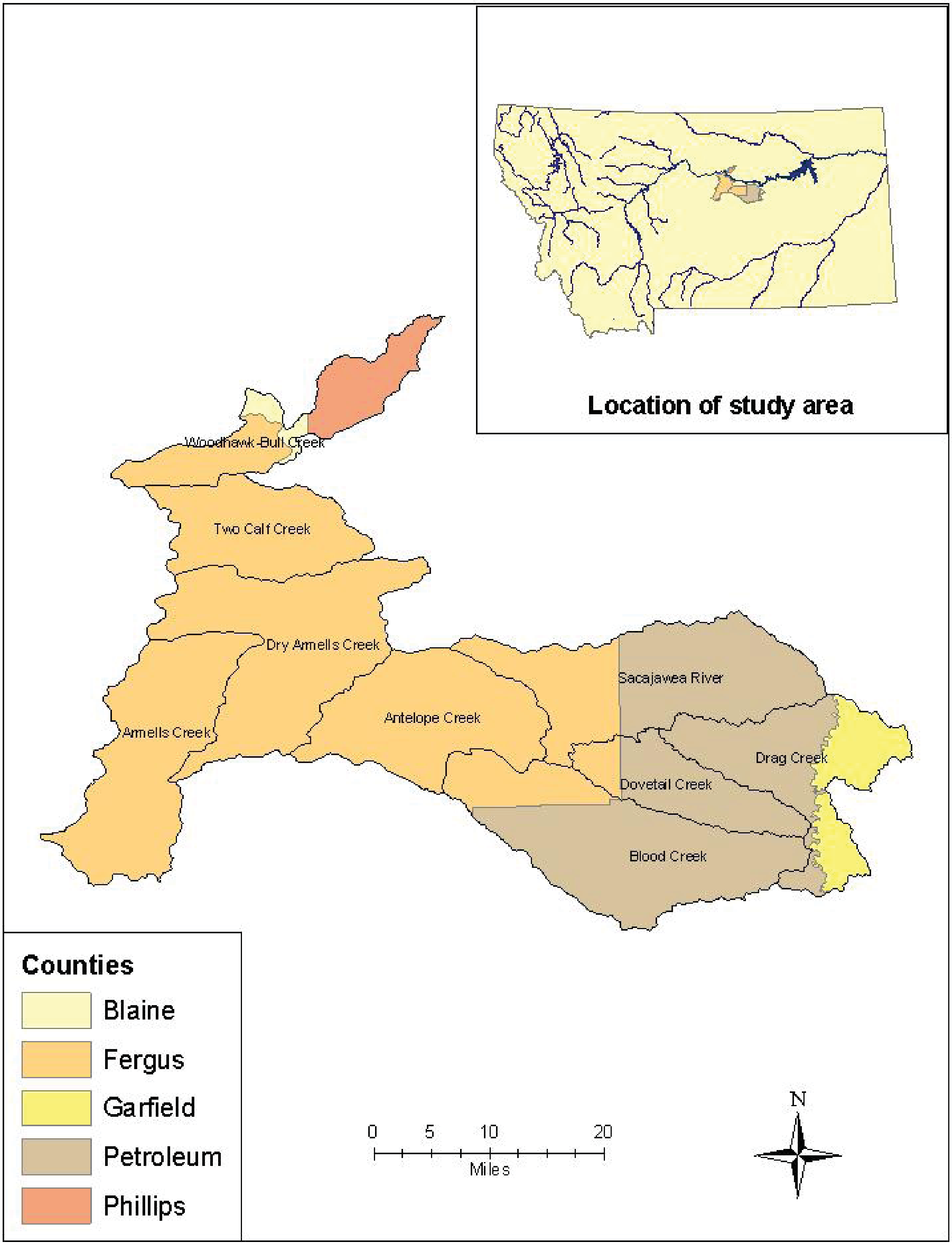

Figure 1. Study area watersheds (dark lines represent watershed boundaries)

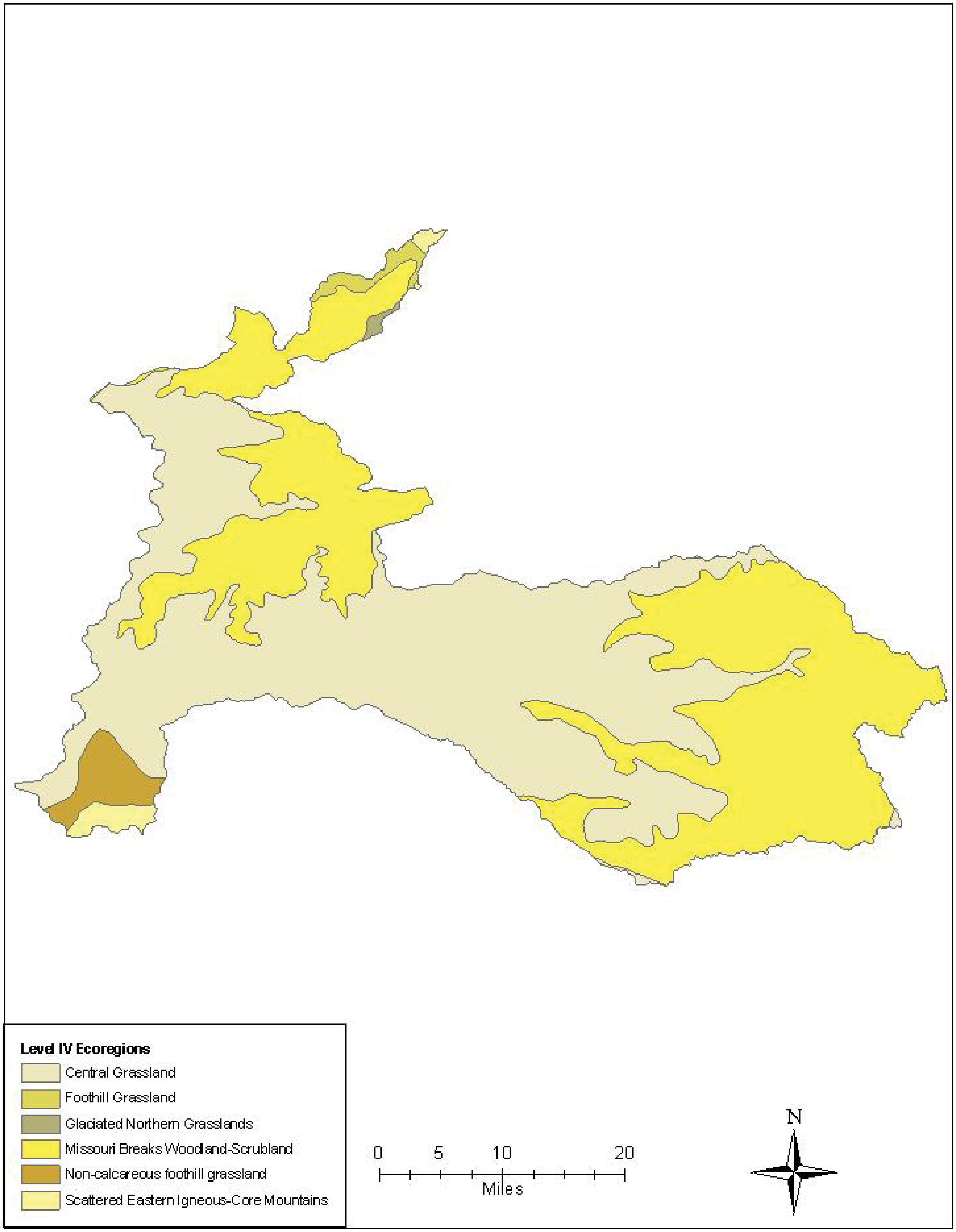

Figure 2. Ecoregions included in the study area

retreats and advances of the inland sea formed basins where shales, sandstones and siltstones were deposited (Figure 3). Most of the study area is comprised of the formations collectively known as the Montana Group, about 1,500 feet thick. These include the Claggett and Bearpaw formations, laid down during the three periods where the sea moved westward towards the Colorado, and the Eagle Sandstone and Judith Formations, left behind during the retreats (Sahni 1972). In the southwestern portion of the study area, the Bearpaw shales are overlain by Fox Hills sandstones, the lithified sediments from the shoreline of the Western Interior Seaway. Above the Fox Hills sandstone is the Hell Creek Formation, deposited by rivers flowing eastward from the Rockies during the last retreat of the inland sea. Many of these formations contain coal and bentonite deposits.

The Little Rocky and Judith Mountains are of more recent origin, formed approximately 55 million years ago by volcanic eruptions that spread across central Montana. Intrusive and extrusive episodes associated with this volcanic activity also brought much older Precambrian gneisses and schists to the surface, especially in the Little Rockies (BLM 1992). Along the edges of the study area, this combination of soft sedimentary rocks and erosion resistant igneous rocks has produced the dramatic landscapes of the Missouri Breaks (Figure 4), where streams created by the receding ice sheets cut deep channels and broad coulees (Figure 5).

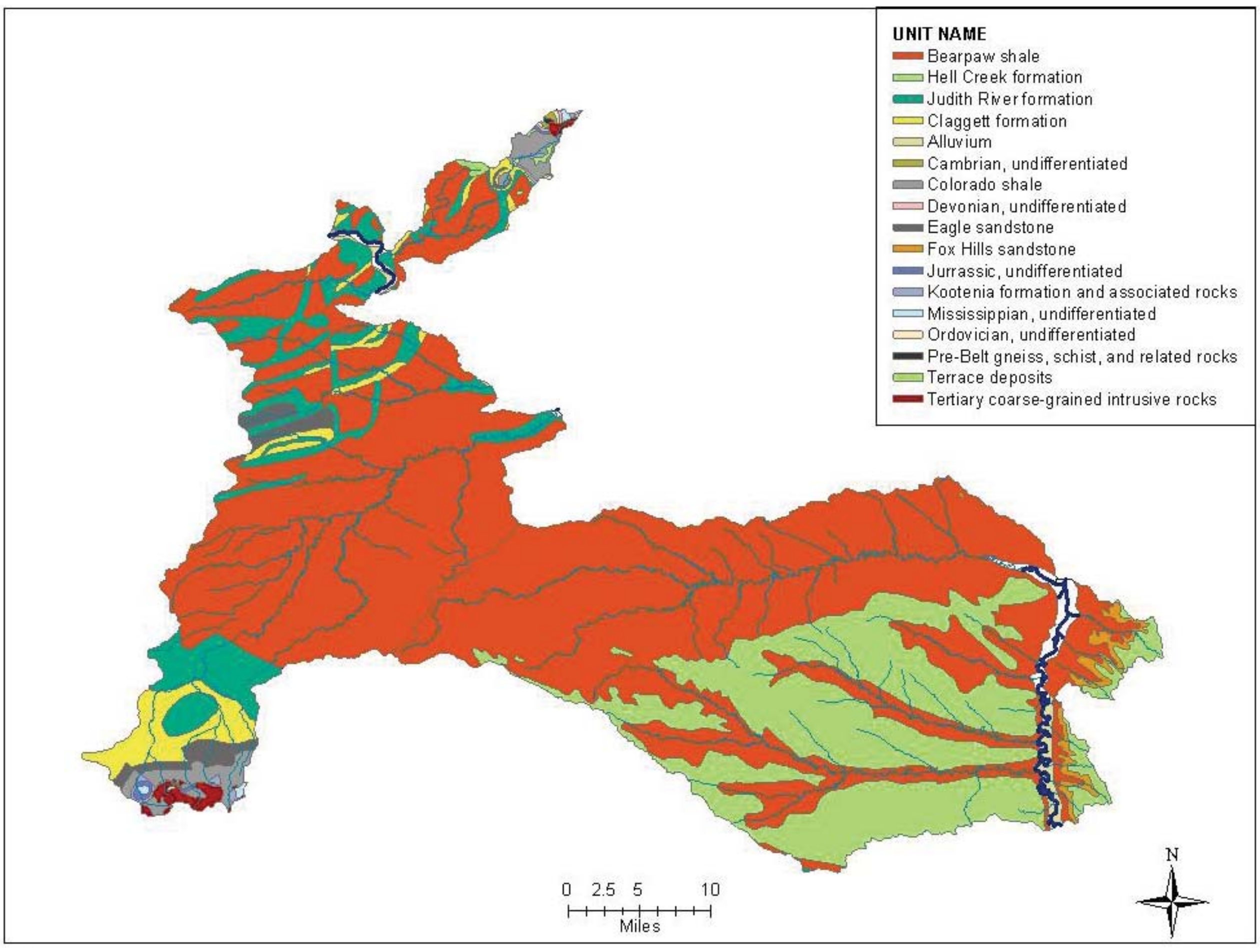

Figure 3. Major geologic units

Figure 4. The Missouri Breaks

Throughout most of the study area, the rolling landforms of the Bearpaw shales are topped by grasslands (Figure 6) and some dry-farmed grain. Soils are primarily clays and shallow clays, weathered from acid and calcareous shales. In the uplands, complex sandy and loamy soil patterns prevail. Soils over the Hell Creek deposits are siltier, and dry-farming of grains is extensive. Grasslands are used primarily as range. The deeply eroded eastern and northern portions of the study

Figure 6. Grasslands north of Judith Mountains

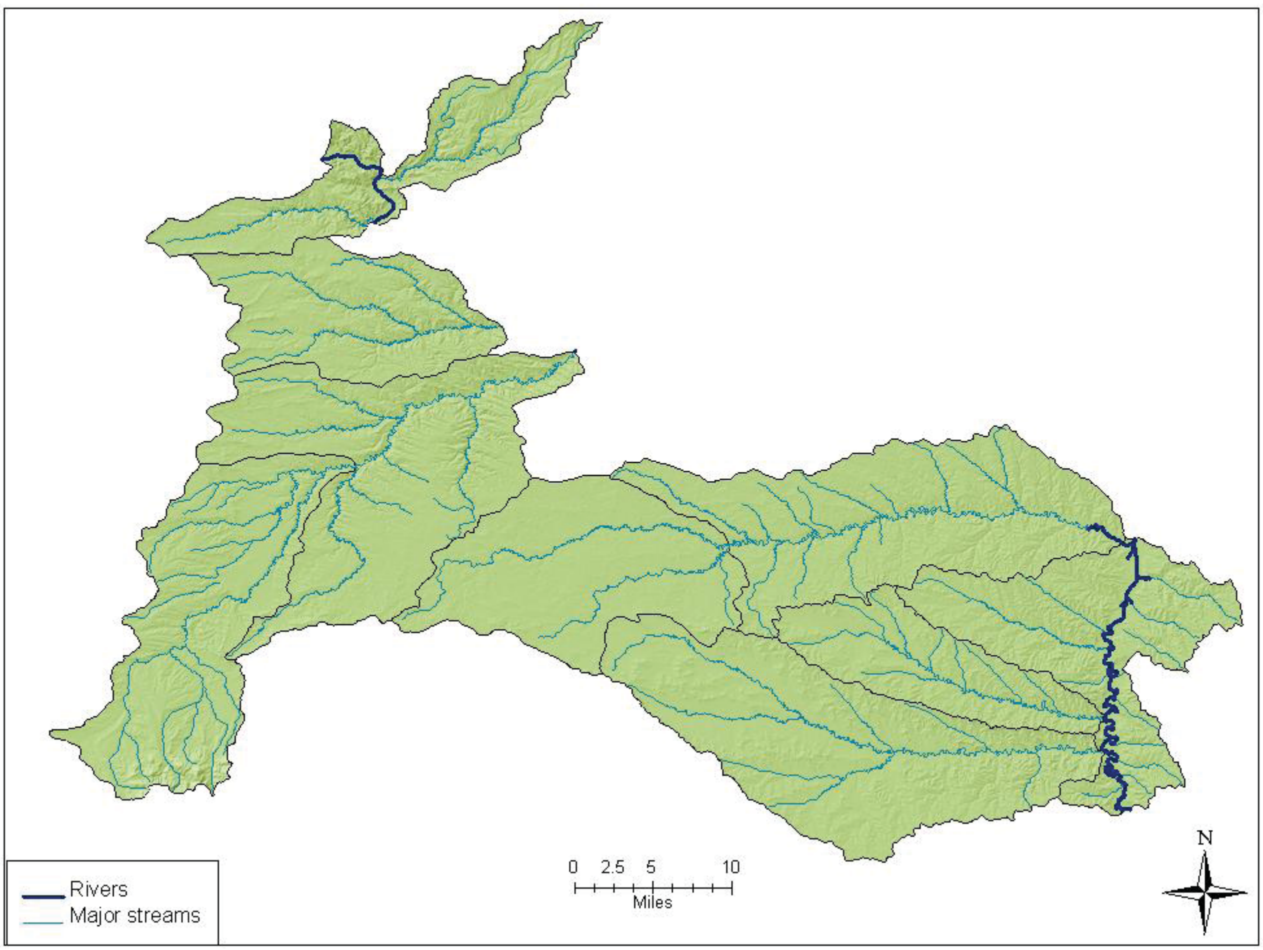

Figure 5. Hillshade of study area with major streams and rivers

area drop abruptly to the Missouri River (north) and the Musselshell River (east). The Missouri's changing course has carved a deep canyon, with broad bottomlands at slow bends (Figure 7). The more sluggish Musselshell River wends through a flat, wide valley where deep, silty clay loams support irrigated alfalfa and non-irrigated grain farming.

Figure 7. Missouri River bottomlands

Along the dissected valley walls of the Breaks, soils are dominated by acid shale, with granular clay surface textures, and little vegetation ground cover. Consequently, they are extremely fragile and highly susceptible to wind and water erosion. In general, the high clay and salt content, fine texture, and often shallow depths of soils in the study area turn unpaved roads into a soupy "gumbo" during rains, although strictly hydric soils are uncommon.

Hydrology

Except for the Missouri River, which flows year round, most of the streams and rivers in the study area are seasonal, with peak flows in spring and summer during snowmelt or rainstorms. Many of the streams are dry by early July (Figure 8). Much of this is due to post-settlement water diversions and impoundments. Lewis and Clark described the Musselshell River, which they encountered on May 20, 1805, as "one hundred and ten yards wide…[It contains more water than streams of that size usually do in this country; its current is by no means rapid, and there is every appearance of its being susceptible of navigation by canoes for a considerable distance. Its bed is chiefly formed of

Figure 8. Dry streambed, Two Calf Creek, mid-July

coarse sand and gravel, with an occasional mixture of black mud; the banks are abrupt and nearly twelve feet high." About five miles upriver, the exploration party encountered another "handsome river of about fifty yards in width," which they named after Sacajawea. Figures 9 and 10 show the present day condition of those rivers; the only water visible in mid-July is the Missouri River, in the distance in Figure 9. Table 1 shows monthly and annual mean flows for the Missouri and Musselshell.

Wetlands in the study area are primarily associated with stock ponds and reservoirs, although both seasonal and permanent wetlands have been incidentally created by high road berms and undersized or poorly-placed culverts interfering with drainage (Figure 11). Most of these wetlands are within the Palustrine Aquatic Bed, Palustrine

Figure 9. Musselshell River near Fort Peck reservoir

Table 1. Monthly and annual mean flows, Missouri and Musselshell Rivers (from McCarthy 2005)

Monthly and anuual mean flows, Missouri River at Landusky (based on 19 years of record)								
October		8440		3270		5530		1530
November		7980		3580		5720		1400
December		7610		3120		5130		1350
January		6490		2800		4690		1150
February		8450		2510		5120		1630
March		13,400		4880		7520		2340
April		19200		5360		10300		4480
May		27200		5260		15100		6850
June		55300		8170		21100		12300
July		17700		3960		9320		4830
August		8250		2080		4840		1720
September		7640		2500		4770		1290
Annual		14,200		4440		8350		2860
Monthly and annual mean flows, Musselshell River at Mosby (based on 73 years of record)								
October		478		0		80		85
November		337		0		79		70
December		278		0		72		63
January		376		0		78		79
February		1860		0		175		282
March		4660		0		458		785
April		1920		3.1		290		357
May		3770		0		522		703
June		4970		1.9		863		1030
July		2150		0		316		473
August		870		0		113		136
September		787		0		111		151
Annual		1090		8.1		268		231

Figure 10. Sacajawea Creek at confluence with Musselshell

Figure 11. Wetland upstream of road berm

Emergent, or Lacustrine systems (Cowardin et al. 1979). Because they depend on dams, roads, culverts, or other human structures for their existence, we rated the majority of the wetlands we surveyed to be functioning at risk. This is discussed in greater detail in the section on fine-scale assessments, below.

Natural Communities

Vegetation

Natural communities within the study area are predominantly grasslands, shrublands, conifer forests, and riparian types. Grasslands contain a mix of native and exotic species. Common native species include western wheatgrass (*Pascopyrun smithii*), thickspike wheatgrass (*Elymus lanceolatus*), little bluestem (*Schizachyrium scoparium*), needle and thread (*Hesperostipa comata*), green needlegrass (*Nassella viridula*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Sandberg bluegrass (*Poa secunda*), blue grama (*Bouteloua gracilis*), plains reedgrass (*Calamagrostis montanensis*), and inland saltgrass (*Distichlis spicata*). Among the non-natives, smooth brome (*Bromus inermis*) and timothy (*Phleum pratense*) are most common in the moister foothill grasslands, while crested wheatgrass (*Agropyron cristatum*) can be found in more or less monotypic stands in drier areas. Common forbs include scarlet vetch (*Vicia americana*), western yarrow (*Achillea millefolium*), globemallow (*Sphaeralcea coccinea*) and the non-native yellow sweetclover (*Melilotus officinalis*). In drier sites, especially in the northern part of the study area, silver sage (*Artemesia cana*), prickly pear (*Opuntia polyacantha*) and rabbitbrush (*Chrysothamnus nauseosus*) are often significant components.

Much of the study area is shrubland, particularly near the Breaks and in the badlands. Big sagebrush (*Artemesia tridentata*) is the dominant shrub, with greasewood *(Sarcobatus vermiculatus*) occurring on more saline soils, especially near Sacajawea Creek. Grasses and forbs include western and thickspike wheatgrass, little bluestem, needle and thread, blue grama, and bluebunch wheatgrass. *Astagalus* sp., fringed sagewort (*Artemesia frigida*), and broom snakeweed (*Gutierrezia sarothrae*) are the most frequently-encountered forbs.

Big sagebrush shrubland vegetation overlaps with the Ponderosa pine-juniper (*Pinus ponderosa-Juniperus scopularum*) forests found along the sloping drainages in the Breaks of the Missouri and Musselshell, and often forms the understory in those forest types. On north and east-facing slopes, Douglas-fir (*Pseudotsuga menziesii*) can be found among the pines and junipers. Douglas-fir is also common in the Little Rocky and Judith Mountains, and is a dominant tree species at some elevations. Lodgepole pine (*Pinus contorta*) and Ponderosa pine dominate drier sites. The north- and east-facing slopes near the top of Judith Mountain are almost exclusively composed of stunted lodgepole pine. Englemann spruce (*Picea engelmannii*) is found in moister

areas. Horizontal juniper (*Juniperus horizontalis*), snowberry *(Symphoricarpos albus)*, rose (*Rosa woodsii*), chokecherry (*Prunus virginiana)*, hawthorn (*Crataegus douglasii*), Oregon grape (*Berberis repens*) and buffaloberry (*Shepherdia canadensis*) are typical understory components in these mountain forests. Unfortunately, many forest stands in these mountainous areas are showing effects of insects and disease, and fire risk is considered to be high (BLM 2006).

Riparian forests within the study area are varied. Around the headwaters of Armells Creek on Judith Mountain, Quaking aspen-red osier dogwood (*Populus tremuloides-Cornus stolonifera*) forests occur, with an understory of water birch (*Betula occidentalis*), snowberry and kinnickinnick (*Arctostaphylos uva-ursi*) mixing with forest grasses, sedges, and non-vascular plants. In the foothills and grasslands, riparian forests are either willow community types, with Sandbar willow (*Salix exigua*), Peachleaf willow (*Salix amygdaloides*) or Yellow willow (*Salix lutea*) dominant, or Box Elder-Chokecherry (*Acer negundo-Prunus virginiana*) types. Snowberry-rose typically dominate the understory. The snowberry-rose community, with scattered sandbar willows, is characteristic of the wet draws and channels around intermittent streams. Along the Missouri and Musselshell, Cottonwood-willow forests are the most common, with box elder and green ash (*Fraxinus pennslyvanica*) interspersed, and a snowberry-rose-buffaloberry understory with western and slender wheatgrass (*Elymus trachycaulus*), needle and thread, green needle grass and Canada wildrye (*Elymus canadensis*). Common forbs include western yarrow, lomatium (*Lomatium simplex*), American vetch (*Vicia americana*), scurfpea (*Psoralidium tenuiflorum*) and milkweed (*Asclepias specisoa*). In general, the cottonwood forests along the Missouri in the western part of the study area exhibit fairly good establishment and survival characteristics. In their study of cottonwoods along the Wild and Scenic portion of the Missouri, Scott et al. (1997) determined floods with a flow greater than 1400 m3/s (measured at Fort Benton) were necessary to create seedbeds high enough above the channel bed that flow- or ice-related disturbances would be minimized. Floods of this magnitude are highly episodic, with an average recurrence interval of 9.3 years (Bovee and Scott 2002), but the fact they exist at all make this one of the few areas in the west with a hydrologic regime appropriate for cottonwood regeneration. However, the riparian forests of the large rivers are challenged by exotic and invasive species. Saltcedar (*Tamarix ramosissima*, *T. chinensis*, and their hybrids) is well established along both the Missouri and Musselshell Rivers. The population of saltcedar has been estimated at upward of 10,000 plants at the mouth of the Musselshell near Fort Peck Reservoir (Pearce and Smith 2003).

Wildlife and Fish

Although much of the study area is used for livestock grazing, hay, or crop agriculture, game and non-game wildlife species are abundant. Antelope (*Antelocapra americana*) herds range across the area, and are especially plentiful near agricultural areas, while mule deer (*Odocoileus hemionus*), white-tail deer (*Odocoileus virginianus*) and elk (*Cervus elephus*) are most common in the Missouri Breaks and bottomlands. Rocky Mountain Bighorn sheep (*Ovis canadensis*), reintroduced to the area in the 1970s and 80s, are also plentiful in the Breaks, and mountain lion (*Felis concolor*), and black bear (*Ursus americanus*) can be found in the Judith and Little Rocky Mountains. Sharp-tailed Grouse (*Tympanuchus phasianellus*) and Greater Sage-Grouse (*Centrocercus urophasianus*) are plentiful, as are the introduced Gray Partridge (*Perdix perdix*), and Ring-necked Pheasant (*Phasianus colchicus*), especially in the Breaks, and coyote (*Canis latrans*), red fox (*Vulpes vulpans*), and raccoon (*Procyon lotor*) are ubiquitous. Colonies of black-tail prairie dogs (*Cynomys ludovicanus)* were observed in the eastern portion of the study area. The extensive cottonwood forests along the Missouri and Musselshell shelter substantial numbers of birds, while bats find attractive habitat in the dissected terrain. A study by Kudray et al. (2004) found Townsend's Big-eared bat, a BLM Sensitive Species, along the Wild and Scenic portion of the Missouri, and noted four other species in the area: silver-haired bat (*Lasionycteris noctivagans*),

hoary bat (*Lasiurus cinereus*), fringed myotis (*Myotis thysanoides*), and long-legged myotis (*M. volans*). The same study noted beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*) along the river bottomlands, and several species of amphibians and reptiles. In the course of field surveys conducted for the present study, MTNHP biologists also observed three bird species of concern, Brewer's Sparrow (*Spizella breweri*), Lark Bunting (*Calamospiza melanochorys*) and Long-billed Curlew (*Numenius americanus*). Table 2 summarizes animal Species of Concern documented in the study area.

Thirty-six native fish species are known to exist in the Wild and Scenic section of the Missouri River, part of which passes through the study area. Four of these species have been identified in the tributaries and in the Musselshell River. Table 3 gives the common and scientific names of the native species, and their BLM status. Species identified in the tributaries are in bold. Four additional introduced species are also found in the study area: black bullhead (*Ictalurus melas*), common carp (*Cyprinis carpio*), green sunfish (*Lepomis cyanelus*) and spottail shiners (*Notropis hudsonius*).

Table 2. Species of concern in the study area

Element occurrences from MTNHP database				
	STATE	GLOBAL	STATE	BLM
SCIENTIFIC NAME	COMMON NAME	RANK	RANK	STATUS
Buteo regalis	Ferruginous Hawk	G4	S2B	SENSITIVE
Centrocercus urophasianus	Greater Sage-grouse	G4	S3	SENSITIVE
Charadrius montanus	Mountain Plover	G2	S2B	SENSITIVE
Spizella breweri	Brewer's Sparrow	G5	S2B	SENSITIVE
Calamospiza melanocorys	Lark Bunting	G5	S3B	
Ammodramus bairdii	Baird's Sparrow	G4	S2B	SENSITIVE
Ammodramus savannarum	Grasshopper Sparrow	G5	S3B	
Scaphirhynchus albus	Pallid Sturgeon	G1	S1	SPECIAL STATUS
Polyodon spathula	Paddlefish	G4	S1S2	SENSITIVE
Oncorhynchus clarkii lewisi	Westslope Cutthroat Trout	G4T3	S2	SENSITIVE
Macrhybopsis gelida	Sturgeon Chub	G3	S2	SENSITIVE
Macrhybopsis meeki	Sicklefin Chub	G3	S1	SENSITIVE
Cycleptus elongatus	Blue Sucker	G3G4	S2S3	SENSITIVE
Sander canadensis	Sauger	G5	S2	SENSITIVE
Cynomys ludovicianus	Black-tailed Prairie Dog	G4	S3	SENSITIVE
Apalone spinifera	Spiny Softshell	G5	S3	SENSITIVE
Erpetogomphus designatus	Eastern Ringtail	G5	S1	
Bird Rookery	Bird Rookery	GNR	SNR	
Physaria brassicoides	Double Bladderpod	G5	S2	SENSITIVE
Psoralea hypogaea	Little Indian Breadroot	G5T4	S2S3	
Phacelia thermalis	Hot Spring Phacelia	G3G4	S1	

Table 3. Montana native fishes in the study area

Common Name	**Scientific Name**	**BLM Status**
Bigmouth buffalo	*Ictiobus cyprinellus*	
Blue sucker	*Cycleptus elongatus*	Sensitive
Brassy minnow	***Hybognathus hankinsoni***	
Brook stickleback	***Culaea inconstans***	
Burbot	*Lota lota*	
Channel catfish	***Ictalurus punctatus***	
Emerald shiner	*Notropis atherinoides*	
Fathead minnow	***Pimephales promelas***	
Flathead chub	***Hybopsis gracilis***	
Freshwater drum	*Aplodinotus grunniens*	
Goldeye	*Hiodon alosoides*	
Iowa darter	*Etheostoma exile*	
Lake chub	***Couesius plumbeus***	
Longnose dace	***Rhinichthys cataractae***	
Longnose sucker	***Catostomus catostomus***	
Mottled sculpin	*Cottus bairdi*	
Mountain sucker	*Catostomus platyrhynchus*	
Mountain whitefish	*Prosopium williamsoni*	
Northern redbelly X	*Phoxinus eos x phoxinus*	Sensitive
Finescale dace	*neogaeus*	
Paddlefish	*Polyodon spathula*	Sensitive
Pallid sturgeon	*Scaphirhynchus albus*	Endangered
Pearl dace	*Semotilus/Margariscus margarita*	Sensitive
Plains minnow	***Hybognathus placitus***	
Pumpkinseed	*Lepomis gibbosus*	
River carpsucker	***Carpoides carpio***	
Sand shiner	***Notropis stramineus***	
Sauger	*Stizostedion canadense*	Sensitive
Shorthead redhorse	***Moxostoma macrolepidotum***	
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	
Sicklefin chub	*Macrhybopsis meeki*	Sensitive
Smallmouth buffalo	*Ictiobus bubalus*	
Stonecat	*Noturus flavus*	
Sturgeon chub	*Hybopsis gelida*	Sensitive
Western silvery minnow	***Hybognathus nuchalis***	
White sucker	***Catostomus commersoni***	

The Human Setting: Prehistory and Early Settlement

Archeologic evidence within the region suggests that human presence began some 12-15,000 years ago with the arrival of hunters in pursuit of bison and (now-extinct) mammoths (BLM 2005). Until the 1700s, most of these prehistoric hunter-gatherer groups were primarily nomadic, locating campsites near exploitable resources, and following the highly mobile bison herds. Food production was negligible. In the 1700s, the acquisition of horses dramatically altered these subsistence patterns, as new-found mobility allowed hunters to range more broadly and exploit bison herds more efficiently. By 1800, cultures in the area had evolved into specialized horse-mounted hunters. In the early 1800s, when white explorers arrived, they found a number of tribes: Blackfeet (Piegan), Gros Ventre, River Crow, and Assiniboine. Mountain Crow, Shoshone, Flathead and Nez Perce were frequent visitors.

The arrival of European explorers marks the beginning of the historic period. Lewis and Clark passed through the study area during May of 1805, recording their encounters with the plants and animals of the area (DeVoto 1997). In the ensuing decades, they were followed by fur traders, and by the 1830s, several trading posts had been established upriver. When steamboats were finally able to reach Fort Benton in 1859, it became a commercial center, and with the next two decades, gold seekers and settlers followed. Throughout the Breaks, woodhawkers plied their trade, cutting timber and hauling it down to the steamboats. Woodhawk Creek, in the northeastern part of the study area, is named after them.

The Stevens Blackfeet Treaty of 1855 had resolved some of the conflicts with tribes in the region, but in the 1870s and 1880s, Blackfeet, Gros Ventre, and Sioux war parties were conducting routine raids on settlements and wagon trains. Building of the Northern Pacific Railway was stalled in North Dakota, and goods were being hauled from Bismarck to the confluence of the Musselshell and Missouri by steamboat, and then overland along the Carroll Trail to Helena. Bad roads and difficult passage made the freight wagons a prime target. Although military outposts had been established near Lewistown and the confluence of the Judith and Missouri Rivers, raids continued. Nevertheless, the pace of settlement also kept up. Significant gold deposits were discovered in the Judith Mountains in 1880, and prospecting had been going on in the Little Rocky Mountains since the 1860s. The most significant change in the area, however, occurred with the construction of the Montana Central Railroad and its merger with the St. Paul, Minneapolis and Manitoba Railroad across the Hi-Line in 1889 (BLM 2005). In 1888, Congress had ratified a treaty creating the Fort Peck, Fort Belknap and Blackfeet reservations, effectively ending the skirmishes between Native Americans and Euro-American settlers. Coupled with the opening of the railway, this laid the ground for a homestead boom. From 1910 until 1918, fueled by a railroad-sponsored promotional campaign, European immigrants streamed into the region, enjoying a short-lived period of high commodity prices, cheap land, and favorable weather. By the end of the First World War, however, a lengthy drought began, continuing until 1925, and in the early 20s, low gold prices forced the closure of most mines in the area. By the end of 1925, over half the homesteaders were gone. Most of those homesteads reverted to the government under the Bankhead Jones Act, and are now managed for grazing by the BLM. By the 1930s, most remaining ranchers had diversified into mixed grain and livestock operations, which is still true today throughout most of the study area, although cattle are now more common than sheep.

METHODS

Broad-scale Remote Sensing Analysis

For this analysis, we have use a broad-scale landscape assessment approach developed in prior watershed studies (Crowe and Kudray 2003, Vance 2005, Vance et al. 2006) to provide a landscape perspective on the natural diversity, current conditions, and potential threats to wetland and riparian habitats. We began by separating the study area into component landscape units so effective comparisons could be made between units. Based on topography, land cover, and field observations, we decided to analyze the landscape both by ecological subsection (See Figure 2) and by individual 5th code hydrologic units (HUCs). The analysis of ecological subsections was restricted to summary statistics. For the 5th code HUCs, we calculated a number of metrics to allow overall comparisons and provide managers with a basis for planning. The 5th code HUC boundaries were taken from U.S. Geological Survey maps.

We conducted a GIS analysis using geographic and statistical data to summarize potential and actual watershed condition, and to compare watershed conditions and threats among the landscape units. The analysis was divided into three parts. The first part assessed "background" or natural conditions in the watershed by describing potential natural communities, and by evaluating hydrologic and topographic complexity. The second part addressed current conditions and disturbances, including land use, ownership patterns, and alterations and impacts to riparian areas. The third part focused on two threats to watershed integrity: riparian loss, and noxious weed invasion. In each part, indices were created or used to facilitate comparison between watersheds. This index-based approach follows a method initially developed by the Northeast Region of the National Wetland Inventory Program (Tiner et al. 2000), modified and expanded by the Montana Natural Heritage Program (Vance 2005, Vance et al. 2006) to address some of the unique conditions in western ecosystems (e.g. grazing impacts, aridity, drought). This methodology is explained in greater detail in subsequent sections.

Because National Wetland Inventory photointerpretations for the study area were never digitized or turned into hard-copy maps, there was no reliable GIS wetland layer available to assess the number, acreage or types of wetlands affected by land use impacts or other stressors. We used high-resolution National Hydrography Dataset maps and aerial photographs to identify some open water wetlands for field assessment, but these were not useful for GIS analysis. GAP maps and National Land Cover Dataset maps allowed broad-scale delineation of some wetland polygons, but the underlying data for these maps is based on 30-meter resolution Landsat images (GAP datasets use these images to produce 90-meter pixels), and so is too coarse to identify wetlands less than 40 hectares (+/- 99 acres) in size. Consequently, we were unable to carry out broad-scale analyses of wetland extent and condition.

The geographic data used in the assessment and in calculating the sub-indices were derived as follows:

1. Natural Complexity Index

a) Hydrologic Complexity Index

• Using the high-resolution National Hydrography Dataset, identify springs, intermittent and perennial streams, and intermittent and perennial lakes, and sum the number and length/area, as appropriate, for each category.

b) Topographic Complexity Index

• Create a topography polygon layer by reclassifying 10-meter USGS Digital Elevation Maps into 25 elevation classes, and sum acreage in each elevation class.

2. Composite Wetland Condition Index

a) Natural Cover Index

• Sum the land cover categories within the watershed boundaries from the 2001 USGS National Land Cover Dataset and separate them into human and natural classes;
• Make a public and private grazing lands layer by combining State Trust Lands and BLM lands with those privately held lands listed in the Cadastral database as having grazing as their primary use;
• Overlay the natural land cover class on the public and private grazing lands layer, and sum the acreage within the overlay.

b) Stream Corridor Integrity Index

• Draw a 50-meter buffer on each side of stream segments in the 1:100,000 USGS National Hydrography Dataset streams layer;
• Overlay the buffered stream segments on the 2001 National Land Cover Dataset;
• Sum the acreage of land cover categories within the buffered areas.

c) Riparian Loss Index

• Draw a 50-meter buffer on each side of stream segments in the 1:100,000 USGS National Hydrography Dataset streams layer;
• Sum the acreage of tree cover, shrub cover and woody wetland cover within the riparian buffer, based on the 2001 National Land Cover Dataset;
• Calculate the difference in acreage between the summed riparian cover and a hypothetical 50% woody riparian cover.

d) Road Disturbance Index

• Buffer all mapped roads by 50 meters on each side;
• Sum miles of stream and river within the 50 meter road buffer zone.
• Calculate number of road crossings per mile of stream/river length.

3. Composite Riparian Threat Index

a) Riparian Grazing Threat Index

• Select all polygons within the buffered stream corridor layer that are indicated as having natural cover in the National Land Cover Dataset;
• Overlay the public and private grazing lands layer on this natural land cover riparian corridor layer;
• Sum all natural land cover acres within public and private grazing lands layer;

b) Noxious weeds threat index

• Create a layer of Public Lands Survey Sections with known occurrences of noxious weeds;
• For each watershed, calculate the percentage of Public Land Survey Sections with known occurrences of noxious weeds.

Field Data Collection and Assessment

During the summer of 2006, MTNHP ecologists carried out Proper Functioning Condition (PFC) assessments at 43 sites, using the methods described in Pritchard et al. (1999), supplemented with MTNHP rapid assessment protocols (Figure 12). Photos were taken at every site. During all phases of data collection, wetlands were classified with the National Wetland Inventory (NWI) system (Cowardin et al. 1979). For both wetland and upland plants, our principle floristic references were Dorn (1984) and the Flora of the Great Plains (Great Plains Flora 1986). All plant nomenclature follows Kartesz (1999). We analyzed our vegetation data to identify plant associations consistent with the National Vegetation Classification System (NVCS, Grossman et al. 1998). This is a hierarchical system combining floristics at the lowest levels (associations and alliances) and physiognomy and climate at the highest levels. Plant associations are defined by the dominant species in the uppermost vegetation layer and any co-dominant species, diagnostic species, or the dominant species of understory vegetation layers.

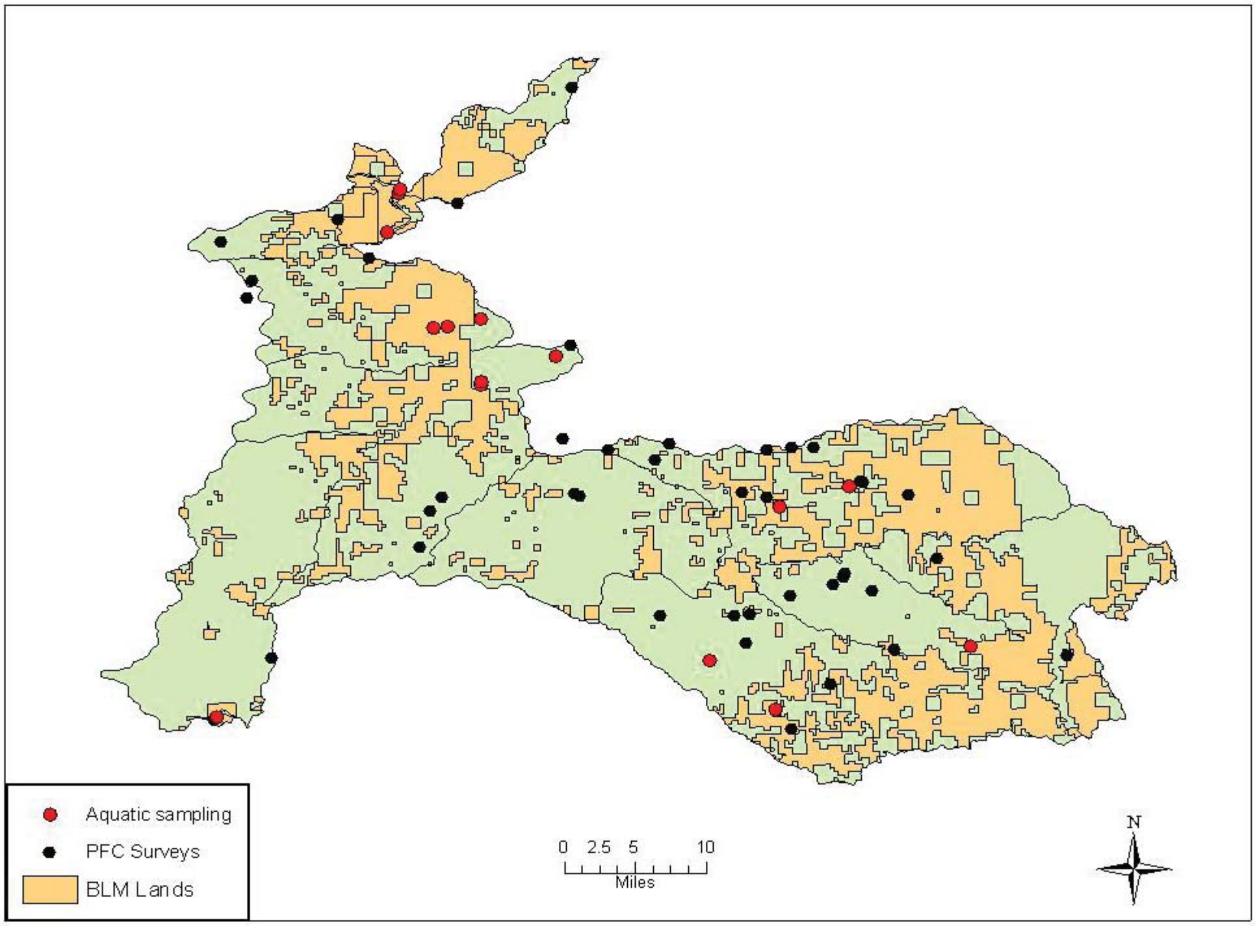

Figure 12. PFC and aquatic survey sites

Riparian habitat assessments, water quality parameter measurements, fish and macroinvertebrate surveys were performed at seven lotic (stream) prairie sites, one mountain-spring influenced and seven lentic (reservoir-ponded) sites. Four of the seven lotic sites had fish, and all had macroinvertebrates. Eight other stream sites were dry. Two streams in the Crooked and Armells Creek drainages were evaluated along a longitudinal sequence using additional biological data. Biological community integrity was calculated at all sites using Fish Integrated Biotic Indices (IBI's) and Observed/Expected Models (O/E), as well as macroinvertebrate multi-metrics (MT MMI).

Results and Discussion

Broad-scale Assessment

Current Conditions

Across the study area, the BLM owns or manages approximately 34.5% of the land. Calculated by ecoregion, BLM ownership is highest in the Missouri Breaks Woodland-Scrubland region (54%), and lowest in the Central Grasslands (18.5%). Almost 54% of the study area is privately owned (Figure 13), with private ownership by watershed ranging from highs of 82% and 84% in Antelope and Armells Creek watersheds, respectively, to a low of 28% in the Drag Creek watershed.

Approximately 59% of the land cover is grassland, 20% is shrubland, and 13% is forest. Wetlands make up less than 0.5% of the landcover. Non-grazing agriculture accounts for the remaining 8% (Figure 14). Both public and private grasslands and shrublands are used primarily for cattle grazing.

Figure 15 shows the extent of grazing use within the study area. Private parcels listed in the cadastral records as having more than 50% of their acreage in grazing are designated “Private Grazing Lands.” Because most BLM and state lands are leased for grazing, those areas are designated as “Public Grazing Lands.” The Charles M. Russell Wildlife Refuge is detailed separately because only portions of the refuge are grazed under an active management plan.

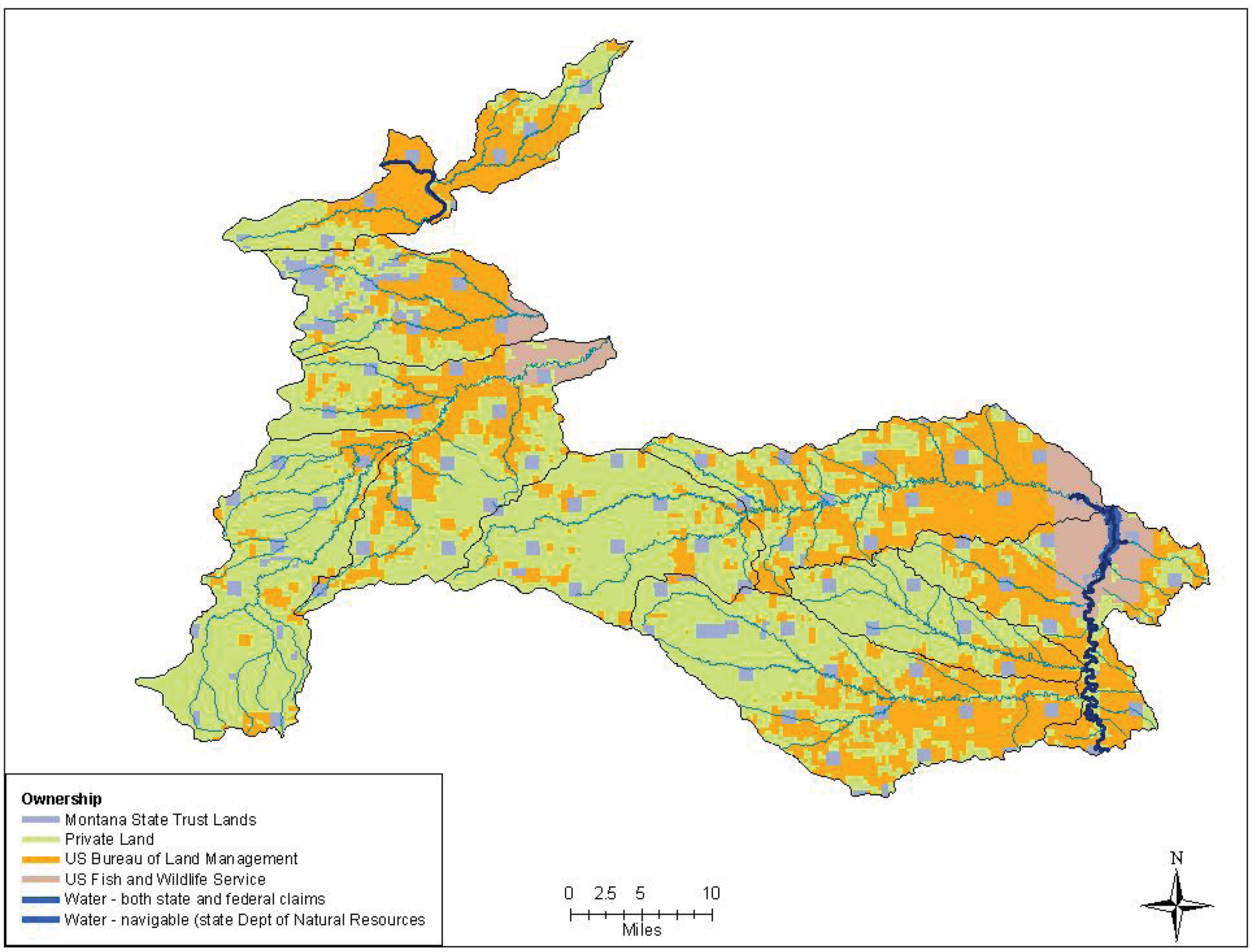

Figure 13. Land ownership and administration

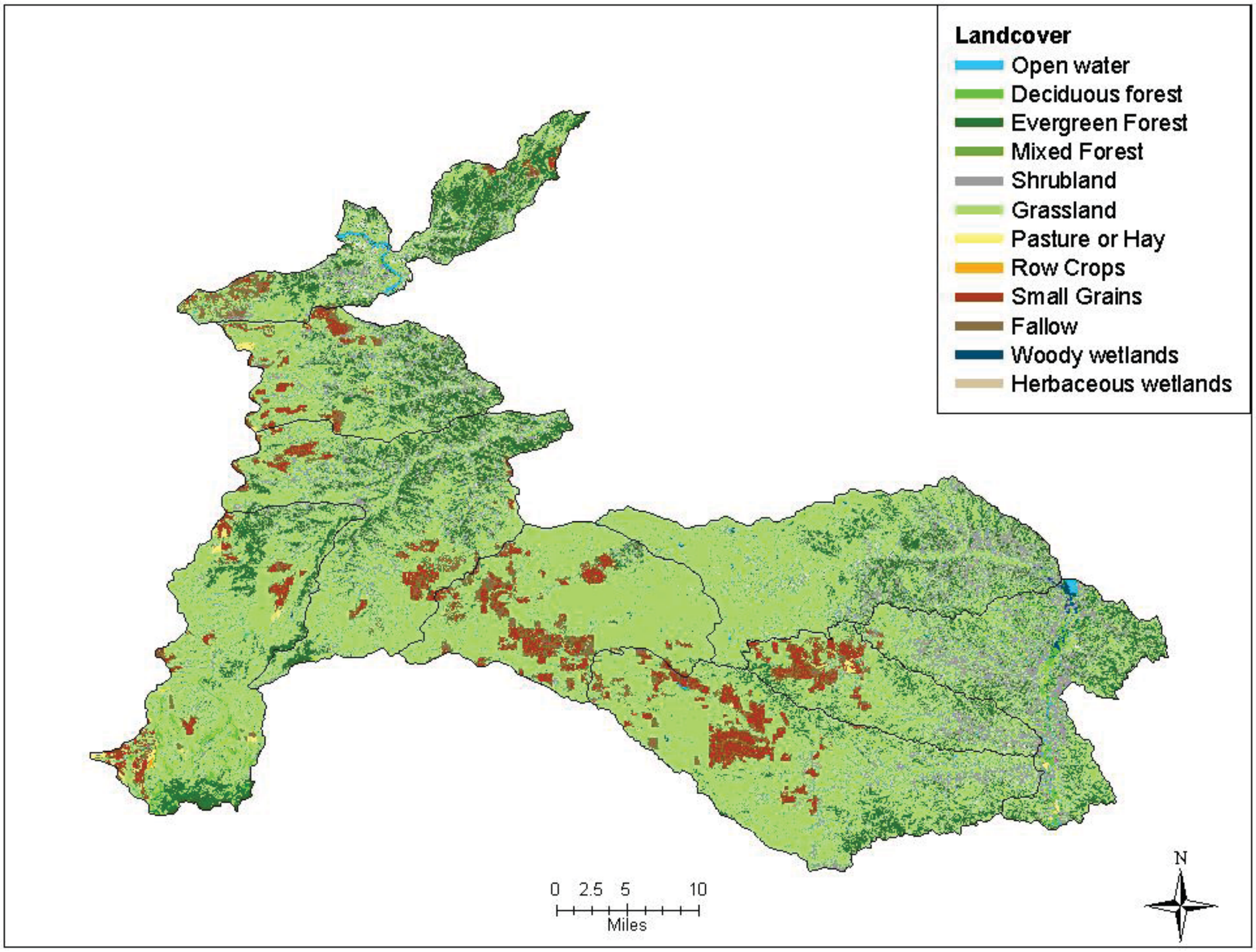

Figure 14. Land cover and land use

The study area encompasses 969,730 acres, of which less than 6,000 acres are in lakes, ponds or other water bodies, mostly manmade. There are 1,634 miles of streams and rivers, based on the 1:100,000 resolution National Hydrography Dataset.[1] Most of these streams are intermittent, flowing only when groundwater levels are high or in response to heavy rain events.

Factors and Magnitude of Change

Since Euro-american settlement began, four human activities have had significant impacts on watershed health and integrity in Montana: timber removal and fire suppression; extraction, diversion and impoundment of water; conversion of grasslands to agriculture; and livestock grazing. Associated impacts such as road-building, and secondary impacts, such as low-intensity residential development, have also altered natural conditions. Mining has also had substantial effects in the state, but most of the mining in this region occurred outside the immediate study area, and with the exception of heavy metal pollution in Armells Creek and (to a lesser extent) the Missouri, direct effects have been limited.

1 The 1:24,000 National Hydrography Dataset is now available for the area, but still contains errors. Moreover, our field studies indicate that many of the stream features shown on the 1:24,000 Dataset and not on the 1:100,000 dataset are ephemeral drainages at best. Therefore we chose to use the medium-resolution Dataset for our calculations.

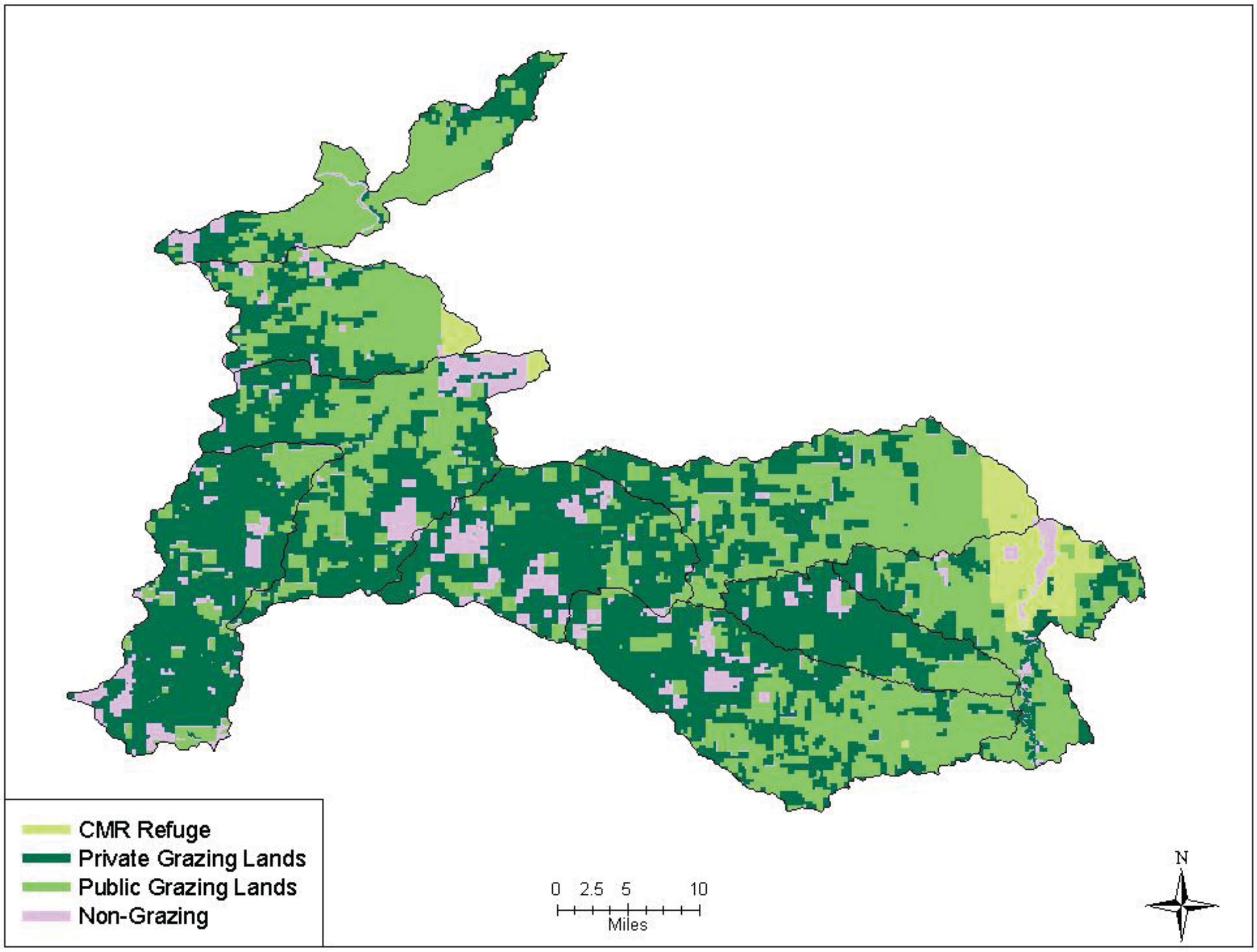

Figure 15. Public and private grazing land

Timber removal

Although woodhawkers cut substantial amounts of timber for steamboats during the heyday of river navigation, conifer forests in the Breaks recovered by the 20th century, and now account for over a third of the timbered land in the study area. Forests in the higher elevation mountains have not fared as well. Post-logging natural re-establishment, coupled with fire suppression, has produced dense, mid-aged stands of Douglas-fir and Ponderosa pine forests with high mortality, low productivity, and considerable susceptibility to insects and disease (BLM 2006).

Extraction, diversion and impoundment of water

The portion of the Missouri River flowing through the study area is designated Wild and Scenic and lies within the Missouri Breaks National Monument. Flows are moderated somewhat by major upstream and downstream impoundments, and influxes from tributary rivers are reduced by diversion and impoundment. Nonetheless, flows prior to irrigation season are sufficient to maintain a more-or-less natural hydrologic regime, with floods and peak flows occurring at regular intervals. The Musselshell, by contrast, is affected both by diversions and withdrawals on the mainstem and tributaries and by Fort Peck Reservoir, into which it flows. Sustained drought has drawn down the Reservoir to the point it no longer extends as far south as the Musselshell (Figure 16), but a series of normal water years could bring levels back.

Across the study area, small dams, diversions and impoundments on headwater and mainstem streams tend to minimize temporal variability in stream flows. By eliminating flood peaks, these dams, diversions and impoundments lead to narrowing and firming of channel beds over time, and to the

Figure 16. Boat launch at Crooked Creek Recreation Site, confluence of Musselshell and Fort Peck Reservoir

loss of bare substrate necessary for successful woody vegetation. Streams in the study area have also downcut significantly over time, and in most areas, only remnant (and decadent) cottonwoods remain. There are currently 2381 dams, diversions, or headwater gates. Density of surface diversions ranges from more than 9 surface water diversions per 100 kilometers of stream length in the Woodhawk, Antelope, and Blood Creek watersheds to approximately 6 in the Drag, Sacajawea, and Dry Armells watersheds. Almost 2/3 of the diversions are in the Central Grasslands ecoregion, where private ownership is highest. Across the study area, 68% of the water rights points of use (which includes both diversions and direct uses) are for stock watering, 14% are for irrigation, and the remainder cover a variety of uses including recreation, fisheries, domestic use, erosion control, and mining.

Within the study area, the Missouri River, Blood Creek, Armells Creek, and the Lower Musselshell have all been evaluated by the Montana Department of Environmental Quality as part of the TMDL process (DEQ 2001).

- The Missouri River from Bullwhacker Creek to Fort Peck Reservoir was found to fully support two of its beneficial uses (agriculture and industrial), partially supporting two others (aquatic recreation and warm water fisheries), and not supporting the fifth (drinking water). Probably causes for impairment were listed as alteration of streamside vegetation, agriculture, livestock grazing, and arsenic and copper contamination.
- Blood Creek was classified as partially supporting a warm water fishery and aquatic life, with impairments being the result of habitat alteration. Because this is not a pollutant, no TMDL was required.
- Armells Creek was found to be impaired from its headwaters to Deer Creek, and not supporting aquatic life or a warm water fishery due to cadmium, copper, arsenic, zinc, and pH. From the confluence with Deer Creek to the Missouri, beneficial uses (aquatic life, warmwater fishery, and primary contact recreation) were all met.
- The 74-mile stretch of the Lower Musselshell, from Flatwillow Creek to Fort Peck was found to partially support aquatic life and a warm water fishery, and to fully support contact recreation. Again, no pollutants were found; causes of impairment were low flows, alterations in vegetations due to agriculture and grazing in riparian and shoreline zones, streambank modifications and destablilization, water diversions, and impacts from resorts.

Conversion of grasslands to agriculture

Grassland conversion can affect watershed health and integrity in a number of ways: first, it is generally accompanied by water withdrawal for agricultural use; second, it eliminates or impedes regrowth of native vegetation while facilitating invasion by weedy species; and third, erosion from tillage and farm roads contributes to increased sedimentation of streams and rivers (Power et al. 1995). In the study area, grasslands account for approximately 58,700 acres, pasture and haylands for 2,500 acres, and row crop, small grain, or fallowed fields for 45,200 acres.

Most of the land identified as grassland on National Land Cover Dataset maps is privately owned, and is used for grazing. While this is not strictly a conversion, both grazing and crop production put heavy demands on water supplied by wells and surface water diversions. There are 351 groundwater rights in the study area, and 2,030

surface water diversions. The study area is also impacted by out-of-area diversions from the Musselshell and its tributaries.

Agricultural conversion also puts aquatic resources at risk through increased erosion and sedimentation. Both the Missouri and the Musselshell carry heavy sediments loads. During 2003-2004, the total sediment measured on the Missouri River at Landusky in May and June (peak flow months) was 514,780 tons and 667,020 tons, respectively. The maximum daily sediment discharge, recorded in June of 1976, was 1,680,000 tons (Berkas et al. 2004). The U. S. Geological Survey has sampled water quantity and quality in the Musselshell at Mosby Bridge for over 25 years, concluding that the average daily sediment load is 735 tons.

Livestock grazing

As noted earlier, livestock grazing is the dominant agricultural use in the study area. Cattle are the most common grazing animals, although sheep are still present in small numbers. Although the Great Plains ecosystems evolved under grazing pressures from hoofed ungulates, the seasonality and intensity of bison and elk grazing differ from current systems. If not managed optimally or effectively, cattle and sheep grazing can cause soil compaction, nutrient enrichment, vegetation trampling and removal, habitat disturbance, and, depending on the season and intensity of use, reproductive failure for native plants and animals. Grazing in riparian areas can cause stream and river bank destabilization, loss of riparian shade, and increased sediment and nutrient loads in the aquatic ecosystem (George et al. 2002). Stock watering tanks can contribute to dewatering of streams and aquifers, and may concentrate livestock movement and congregation in sensitive areas. During hot summers, cattle and sheep prefer to loaf in shady areas, trampling understory vegetation.

Although we saw individual examples of overgrazing, and sheep and cattle in riparian areas, we did not see widespread evidence of improper grazing or substantial degradation of aquatic resources by livestock. However, we did note that non-native grasses and forbs were evident in almost all of the grasslands in the study area

Broad-Scale Assessment Indices

In previous watershed assessments (Crowe and Kudray 2003, Vance 2005, Vance et al. 2006), the Montana Natural Heritage Program developed a method for broad-scale assessment of wetlands based on a procedure originally developed by the Northeast Region of the U.S. Fish and Wildlife National Wetland Inventory Program (Tiner et al. 2000). We have continued to refine this method by adding new metrics, dropping redundant or insensitive metrics, and refining scoring for land-use categories. We believe these ongoing refinements provide a better baseline for assessment, and more accurately evaluate the stressors found in western watersheds.

This assessment procedure has three components. First, we generated a Composite Natural Complexity Index, based on underlying hydrologic and elevation factors, to capture the extent and variation of natural conditions within the overall study area and the individual watersheds. Each of the sub-indices is scaled from 0.0 to 1.0, with higher scores reflecting greater complexity. In earlier assessments, we were also able to evaluate wetland diversity as part of this index; in this study area, where there are no National Wetland Inventory maps, this part of the assessment could not be performed. However, our field surveys indicated very little wetland diversity in these watersheds, and indeed, very few natural wetlands.

Next, we used two sub-indices of habitat extent and two sub-indices of disturbance to produce the overall Composite Watershed Condition Index (CWCI). This index gives a sense of how much pre-settlement habitat remains in the study area watersheds, emphasizing riparian systems and adjacent upland habitat, i.e. buffers. In this step, higher scores on the habitat sub-indices represent more optimal conditions, while higher scores on the disturbance sub-indices indicate potential problems. The habitat indices are added together and the disturbance indices are subtracted from this sum to create the Composite Watershed Condition Index (CWCI) for each 5th code HUC.

In the final step, we calculated a Composite Wetland Threat Index. Because both grazing and noxious weeds have the potential to degrade wetlands and riparian areas over time, we have included them both as current disturbances and future threats. Here, higher scores signal a higher level of threat.

One criticism of indices of biological integrity is that individual characteristics of the system being assessed are blurred by the act of collapsing multiple metrics into a single number (Moyle et al. 1999). To offset this danger, we have chosen to keep the three overall indices distinct from one another. This way, characteristics of each watershed can be compared without significantly diminishing the magnitude of specific disturbances or threats.

Composite Natural Complexity Index

In past assessments, we used diversity indices to characterize the inherent natural features of the watersheds, reasoning that these underlying factors can influence both overall condition and the severity of threats. Diversity indices are mathematical measurements of community composition, typically used to assess species diversity, although they are sometimes used at the landscape level. Here, we depart from that practice in favor of a "Natural Complexity Index," which we feel captures the variability inherent in the study area without complex mathematical analysis. The Natural Complexity Index measures the richness and extent of hydrologic features and topography. It has two subindices, the Hydrologic Complexity Index and the Topographic Complexity Index, explained below.

Hydrologic Complexity Index (I_{HC})

The Hydrologic Complexity Index describes the number and density of hydrologic features in a watershed (springs, seeps, perennial lakes and streams, and intermittent lakes and streams). By characterizing the number and extent of these features, this subindex allows managers to prioritize watersheds for management efforts or further assessment. Although many of the lakes and ponds are manmade, we have included them in the analysis because they provide significant habitat when managed for those values.

We calculated this index by summing 1) the number of springs and seeps, 2) the number of perennial and intermittent lakes; and 3) the density of perennial and intermittent streams and lakes (in square miles of lake per square miles of watershed, or total miles of stream per square miles of watershed). Each of the nine watersheds received a rank of 1-9 in each category (number of springs; number of perennial lakes; number of intermittent lakes; square miles of intermittent lakes per square miles of watershed; square miles of perennial lakes per square mile of watershed; miles of intermittent stream per square miles of watershed; and miles of perennial stream per square miles of watershed). Low scores in a category meant the watershed had the lowest number of density of the feature in question. Scores were summed across the categories, and averaged for each watershed. To convert them to a scale of 0 to 1, we took the log of the score. This was then relativized by taking the highest log score, and dividing all other scores by that score.

Based on this analysis, the Armells Creek watershed has the most hydrologic complexity. The Dovetail, Antelope, Dry Armells and Two Calf watersheds have slightly lower scores, but all have good complexity based on the type and distribution of features in the study area. The Drag and Woodhawk Creek watersheds have the least hydrologic complexity. Table 4 shows the individual scores on this metric.

Table 4. Hydrologic Complexity Index scores

Watershed		Score
Armells		1.00
Dovetail		0.98
Antelope		0.95
Dry Armells		0.94
Two Calf		0.94
Blood		0.68
Sacajawea		0.68
Drag		0.54
Woodhawk		0.44

Topographic Complexity Index (I_{TC})
Elevations in the study area range from 684 to 1,947 meters (2,284 to 6,388 feet) above sea level. This score was calculated by using a GIS to create 25 equal elevation bands (+/- 50 meters each) across the study area. We summed the number of elevation bands in each watershed, took the log of that sum, and relativized the scores by dividing each log score by the highest log score. Table 5 shows the scores on this metric. The Armells Creek watershed (which extends up Judith Mountain) has the most topographic complexity, while Drag Creek (which is part of the Breaks area around the Musselshell) has the least.

Table 5. Topographic Complexity Index scores

Watershed		Score
Armells		1.00
Woodhawk		0.92
Dry Armells		0.79
Two Calf		0.66
Blood		0.64
Sacajawea		0.62
Dovetail		0.60
Antelope		0.57
Drag		0.51

Composite Natural Complexity Index (CNCI)
We combined the two sub-indices into a Composite Natural Complexity Index. Table 6 shows the scores on this composite metric. As the scores indicate, the Armells Creek watershed has the most overall complexity among the study area watersheds, scoring highest on both hydrology and topography metrics.

The Armells and Dry Armells watersheds both include perennial stream reaches, as well as having the greatest combined length of intermittent streams. Armells occupies a higher elevation position than Dry Armells, extending from the top of the Judith Mountains to the grasslands (Figure 17), and Dry Armells runs from the Judith Mountain foothills to the Missouri River. Both include mixed conifer forests, grasslands and shrublands. Upper reaches of Armells Creek are surrounded by aspen, and there are several willow complexes in the grasslands. Dry Armells contains extensive Ponderosa pine forests, and several stands of cottonwood near the confluence of Armells Creek and the Missouri.

Table 6. Composite Natural Complexity Index scores

Watershed		Score
Armells		1.00
Dry Armells		0.87
Two Calf		0.80
Dovetail		0.79
Antelope		0.76
Woodhawk		0.68
Blood		0.66
Sacajawea		0.65
Drag		0.53


Figure 17. Armells Creek watershed

Composite Watershed Condition Index
The Composite Watershed Condition Index is made up of four sub-indices. Two habitat extent indices measure the degree to which the watersheds in the study area retain the natural conditions believed to have existed prior to Euro-American settlement: the Natural Cover Index and the Stream Corridor Integrity Index. Each of these indices has

a score between 0 and 1, with 0 representing the greatest departure from natural conditions, and 1 representing the least departure. These indices are complemented by two disturbance indices that assess the extent of alterations and other disturbances affecting watershed condition: the Riparian Loss Index and the Road Disturbance Index. Each of these indices also has a score between 0 and 1, with 0 representing the lowest level of disturbance and 1 the highest. To arrive at an overall determination of wetland condition, we summed the two habitat extent sub-indices and then subtracted the summed disturbance sub-indices. Each of these is explained below.

Habitat Extent Indices

Natural Cover Index (I_{NC})

The Natural Cover Index measures the amount of grassland, forest, shrubland, and wetlands/lakes relative to the total land area in the watershed. Because human activities in watersheds can have far-reaching effects on wetland hydrology, water quality, vegetation, soil development, and nutrient cycling at both the site and watershed scale, more land in natural cover within a watershed contributes to better overall condition. Inversely, a low score suggests substantial loss of watershed function.

The Natural Cover Index was initially developed for use in the Northeast, where livestock grazing is not as widespread, and consequently it does not account for the impacts of grazing on natural cover. Although grasslands in the western U.S. evolved under grazing regimes, the brief, intense grazing patterns characteristic of bison and elk are not reproduced by cattle, and plant community composition can shift radically under continued, season-long grazing, especially if cattle are stocked heavily. The original Natural Cover Index also does not distinguish between non-natural land use categories; for example, a watershed with 75% of its land in natural cover and 25% in dry-farmed agriculture would receive the same score as a watershed with 75% of its land in natural cover and 25% in high-intensity residential and commercial development. Therefore, we used a weighting system based on the methodology developed by Hauer et al. (2001, 2002) for field-based landscape assessments, adapting that methodology to the analysis of 2001 National Landcover (NLCD) data sets. In this system, land uses derived from the NLCD are weighted as follows:

Use	**Weight**
Other	0.5
Open Water	1.0
Low intensity residential	0.3
Commercial, industrial, transportation	0.0
Bare rock, sand or clay	1.0
Deciduous forest	1.0
Evergreen forest	1.0
Mixed forest	1.0
Shrubland	1.0
Grassland or herbaceous	0.7
Pasture or hay	0.6
Cultivated crops/Fallowed land	0.2
Developed, open space	0.4
Herbaceous wetlands	1.0
Woody wetlands	1.0

In this weighting system, all grasslands are assumed to be grazed. Hauer et al. (2001) assigned weights from 0.2 to 0.7 depending on grazing intensity, but this was not possible from remotely-sensed data. Instead, we assumed grazing across all grasslands could be weighted as “light,” or 0.7, since some grasslands would only be grazed sporadically.

The Natural Cover Index is then calculated as:

$I_{NC} = A_{LCWt}/A_W$,

where A_{LCWt} = sum of the weighted scores for land cover in acres, and A_W = total area in the watershed. For the study area as a whole, the Natural Cover Index score is 0.78. Scores for the individual watersheds are shown in Table 7:

The watershed with the most natural land cover is Drag Creek. Except for the agriculturally developed Musselshell River valley, this is a remote and little-developed area mostly in federal ownership. However, it should be noted this score may not reflect the impacts of grazing in riparian areas; woody wetlands --in this case, the cottonwood forests along the Musselshell River--

Table 7. Natural Cover Index scores

Watershed		Score
Drag		0.85
Dry Armells		0.82
Woodhawk		0.82
Two Calf		0.81
Sacajawea		0.80
Armells		0.79
Blood		0.73
Dovetail		0.73
Antelope		0.67

are scored as a natural feature. Nonetheless, even if woody wetlands were given a weighted score of 0.7 to reflect grazing, the Drag Creek watershed would still have the highest score on this index. Grazing impacts in riparian areas are reflected in the Stream Corridor Integrity Index, below.

The Antelope Creek watershed has the lowest score of any in the watershed, reflecting the high proportions of grassland and cropland. This watershed also has one of the highest percentages of privately owned land (82%).

Stream Corridor Integrity Index (I_{SCI})

The Stream Corridor Integrity Index measures the amount of natural land cover within a set buffer on either side of all perennial and intermittent streams. It was calculated by creating a 50-meter buffer on each side of the stream segments in the 1:100,000 National Hydrography Dataset. Although higher resolution stream data is available and was used in other calculations (e.g. the Hydrologic Complexity Index), it includes many ephemeral streams and drainages where transport of sediment, runoff and pollution may be minimal. By using lower-resolution data, we hoped to capture perennial and intermittent streams while avoiding ephemeral drainages.

This index offers a way to determine whether areas adjacent to streams are contributing more than natural amounts of sediment, runoff and pollution. Croplands and fallow fields will produce higher sedimentation rates than naturally vegetated areas (Wilkin and Hebel 1982), and activities creating impermeable cover (particularly roads and commercial, industrial or residential development) will lead to elevated runoff levels, as well as overland transport of chemical pollutants.

Like the Natural Cover Index, the Stream Corridor Integrity Index as developed by Tiner (2000) is generally a simple ratio of naturally vegetated stream corridor to total stream corridor area, with no allowance made for either grazing impacts or types of non-vegetation cover. Accordingly, we weighted the various land uses as we did in the Natural Cover Index, adjusting our assumptions and the assigned weights slightly to reflect the difference in both use and impacts of land use activities on riparian versus upland systems. We assumed, for example, that grazing pressure would be better characterized as “moderate” than as “light” in riparian grasslands, as cattle are prone to congregate near sites offering shade and water, but the lushness of riparian grasslands makes them somewhat more resistant to grazing than more water-stressed uplands. Following Hauer et al. (2002), we therefore gave grasslands in the stream corridor (which we assume are all grazed) a weight of 0.6. Again following the weights assigned by Hauer et al. (2002) for riparian corridors, we changed the weight assigned to Hay or Pasture from a 0.6 to a 0.5 to reflect the higher risk of erosion, sedimentation and nutrient enrichment from agricultural activities near a stream. However, we did not change the weights of crop and grain production, which were already low (0.2). The weights we used for individual activities in the calculation of the Stream Corridor Index were:

Use	**Weight**
Other	0.5
Open Water	1.0
Low intensity residential	0.0
Commercial, industrial, transportation	0.0
Bare rock, sand or clay	1.0
Deciduous forest	1.0
Evergreen forest	1.0
Mixed forest	1.0
Shrubland	1.0

Grassland or herbaceous	0.6
Pasture or hay	0.5
Cultivated crops/fallowed land	0.2
Developed, open space	0.4
Herbaceous wetlands	1.0
Woody wetlands	1.0

We then calculated this index as:

$I_{SCI} = A_{LCWt}/A_{TC,}$

where A_{LCWt} = the sum of the weighted scores for land cover in acres and A_{TC} = total stream corridor area, in acres.

We report 50 meters as the buffer width on each side of the streams (100 meters total) because many of the tributary corridors are in relatively confined valleys, but we found little difference between scores calculated with 50, 100, and 150 meter buffers. As can be seen from Table 8, the Drag Creek and Antelope watersheds occupy the same positions (best and poorest) that they did with the Natural Cover Index. This index shows more spread among the nine watersheds, reflecting the concentration of human land uses in valleys and around water sources. In all cases, however, the scores came under downward pressure by the amount of grassland within the stream corridor, and the assumption it was moderately grazed. For the most part, the scores on this metric are relatively high, indicating there is fairly limited cropping and development around perennial and intermittent streams.

Table 8. Stream Corridor Integrity Index scores

Watershed		Score
Drag		0.87
Two Calf		0.82
Sacajawea		0.77
Dry Armells		0.77
Woodhawk		0.76
Armells		0.74
Dovetail		0.71
Blood		0.68
Antelope		0.60

Habitat Disturbance Indices

Riparian Loss Index (I_{RL})

Land use activities within the stream and river corridor are one measure of the departure from natural conditions; another is direct loss of riparian vegetation. This is especially true along the major streams and rivers in the region of the study area, where cottonwoods, willows and mixed forests should be dominant land cover features. To approximate riparian loss, we used the 2001 National Land Cover Dataset to create a vegetation layer that includes tree and shrub riparian types (including woody wetlands). We buffered all streams from the 1:100,000 National Hydrography Dataset by 50 meters on each side, and calculated the acres of riparian vegetation.

To be on the conservative side, and recognizing the inaccuracies inherent in land cover data at this resolution, we assumed under natural conditions, the riparian corridor would include at least 50% tree and shrub vegetation. Any departure from that was considered to be a loss. The index was calculated as:

$I_{RL} = 1 – (A_{RV})/ (0.50 *A_{TR}),$

where A_{RVT} and A_{RVPR} = the acreage of riparian vegetation within the buffered corridor, and A_{TR} = the total riparian corridor area, in acres.

Table 9 shows the scores for each watershed; high scores indicate a greater level of disturbance, while low scores equals less disturbance. The spread was quite dramatic. Scores ranged from a high of 0.77 for the Sacajawea watershed to lows of 0 for the Woodhawk, Two Calf, and Drag watersheds. In fact, although we did not use negative scores, both the Woodhawk and Drag watersheds had more than 50% of their riparian corridors covered by trees and shrubs. We surmise these low scores are largely a function of the topography of these watersheds; all three are in the Breaks ecoregion, and are characterized by steep, confined stream valleys not amenable to agricultural development. The higher-scoring watersheds all have extensive agriculture or grazing, and the decadent remnants of cottonwoods suggest there has been a significant

loss of woody riparian vegetation since pre-settlement times.

Table 9. Riparian Loss Index scores

Watershed		Score
Sacajawea		0.77
Antelope		0.75
Dry Armells		0.70
Blood		0.42
Armells		0.28
Dovetail		0.20
Woodhawk		0.00
Two Calf		0.00
Drag		0.00

Road Disturbance Index (I_{RD})

Both improved and unimproved roads compact or cover soil and vegetation, increasing surface runoff (Castelle et al. 1994). Road rights of way are often fertile ground for exotic species to colonize, and unimproved roads contribute to wind and water-borne erosion and sedimentation. Streams and riparian areas in close proximity to roads are more likely to be affected than those at a greater distance. Because this area is exceptionally dusty during summer months, we chose a 50-meter buffer on each side of the road.

The Road Disturbance Index is calculated as:

$$I_{RD} = ((L_{SR}/L_S) + (RC/ L_S)) / 2$$

where LSR = the length of perennial and intermittent streams within 50 meters of a road, in miles, L_S = the total length of perennial and intermittent streams in miles, and RC = the number of road crossings.

We found in general, roads and road crossings are not a major disturbance factor to streams in the study area (Table 10). This was born out by our field surveys, where we noted many roads, especially in the breaks, follow ridgelines instead of valleys. Road density ranges from a high of 0.86 linear miles per square mile of area in the Blood Creek watershed to a low of 0.18 linear miles per square mile of area in the Dry Armells Creek watershed. There were no intermittent or perennial streams or rivers within 50 meters of a road in any watershed, except where roads crossed streams (Figure 18) Stream crossings were also relatively uncommon, except in the Blood Creek watershed.

Table 10. Road Disturbance Index scores

Watershed		Score
Blood		0.30
Drag		0.07
Armells		0.05
Antelope		0.05
Woodhawk		0.04
Sacajawea		0.03
Dovetail		0.03
Dry Armells		0.02
Two Calf		0.01

Figure 18. Road crossing, lower Dovetail Creek

Because there were no streams within the 50-meter road buffer, this subindex is really a measure of stream crossings per mile of stream (RC/ L_S). Blood Creek and Two Calf score highest and lowest, respectively. As noted above, the Blood Creek watershed has the highest road density of any of the study area watersheds, so this is not surprising, although the raw number of crossings (100) is itself high. Twenty of the crossings appear to be on BLM land.

Of course, this index does not take the type or nature of crossings into account; for example, it does not distinguish between paved roads over bridges, improved roads with culverts, and dirt roads crossing stream beds directly. Nor can it pick up the condition of culverts. Culvert design and maintenance can have substantial impacts on aquatic health, especially in areas where roads are minimally maintained. (Furniss et al. 1991). However, it gives some insight into potential management issues in the study area.

Composite Watershed Condition Index (CWCI)
The Composite Watershed Condition Index is calculated by subtracting the combined disturbance indices from the combined habitat extent indices:

$$CWCI = (I_{NC} + I_{SCI}) - (I_{RL} + I_{RD})$$

The highest possible score would be 2.00, assuming scores of 1.00 (best) on each of the habitat extent indices and 0.00 (best) on each of the disturbance indices. This score would represent the sort of pristine conditions associated with remote, ungrazed wilderness areas with no history of mining, agriculture or other significant human land use. For inhabited areas, scores will obviously be much lower, and can be a negative number when habitat indices are low and disturbance indices are high. In theory, a watershed in a highly urbanized area with multiple disturbances, alterations, and diversions could score as low as –2.00. Inhabited rural watersheds should score between -1.25 and 1.25, depending on the level of grazing, agriculture and development.

The Composite Watershed Condition Index scores for the study area watersheds are shown in Table 11 and in Figure 19. All the watersheds received positive scores, ranging from highs 1.65 and 1.62 for the Drag and Two Calf watersheds, respectively, to a low of 0.47 for the Antelope Creek watershed. In general, these scores indicate the presence of mild to moderate impacts on watershed health and integrity. The three highest-scoring watersheds all have high percentages of BLM-managed land, are relatively remote, and have low percentages of private ownership. Private ownership in Drag Creek is less than 19%, with most of it restricted to the Musselshell River valley. BLM and the US Fish and Wildlife Service own most of the remaining land, with state school parcels comprising the rest. By contrast, the low-ranking Antelope Creek watershed has only 15% of its lands under BLM Management.

Table 11. Composite Watershed Condition Index scores

Watershed		Score
Drag		1.65
Two Calf		1.62
Woodhawk		1.54
Dovetail		1.21
Armells		1.20
Dry Armells		0.87
Sacajawea		0.77
Blood		0.69
Antelope		0.47

Composite Watershed Threat Index
The Composite Watershed Condition Index is a measure of how much natural conditions have changed in individual watersheds, since Euro-American settlement. The Composite Watershed Threat Index, on the other hand, is an attempt to predict which watersheds are most likely to experience continued or future change and loss of integrity. As is true in other study areas, the rate of change has probably slowed in the past few decades. Road- and dam-building, irrigation ditching and homestead establishment would have been most intense in the first few decades of settlement, and residential development associated with Lewistown is mostly to the immediate west of the study area. In the coming decades, however, activities associated with energy development may exert significant pressures on the area. Currently, there are few oil and/or gas leases in the study area, with most in the extreme southern portion of the Blood Creek watershed, and in the northeastern portion (the Bull Creek side) of the Woodhawk-Bull Creek watershed. The Judith River Formation, relatively exposed in the Woodhawk, Two Calf, Dry Armells and Armells Creek watersheds, is a

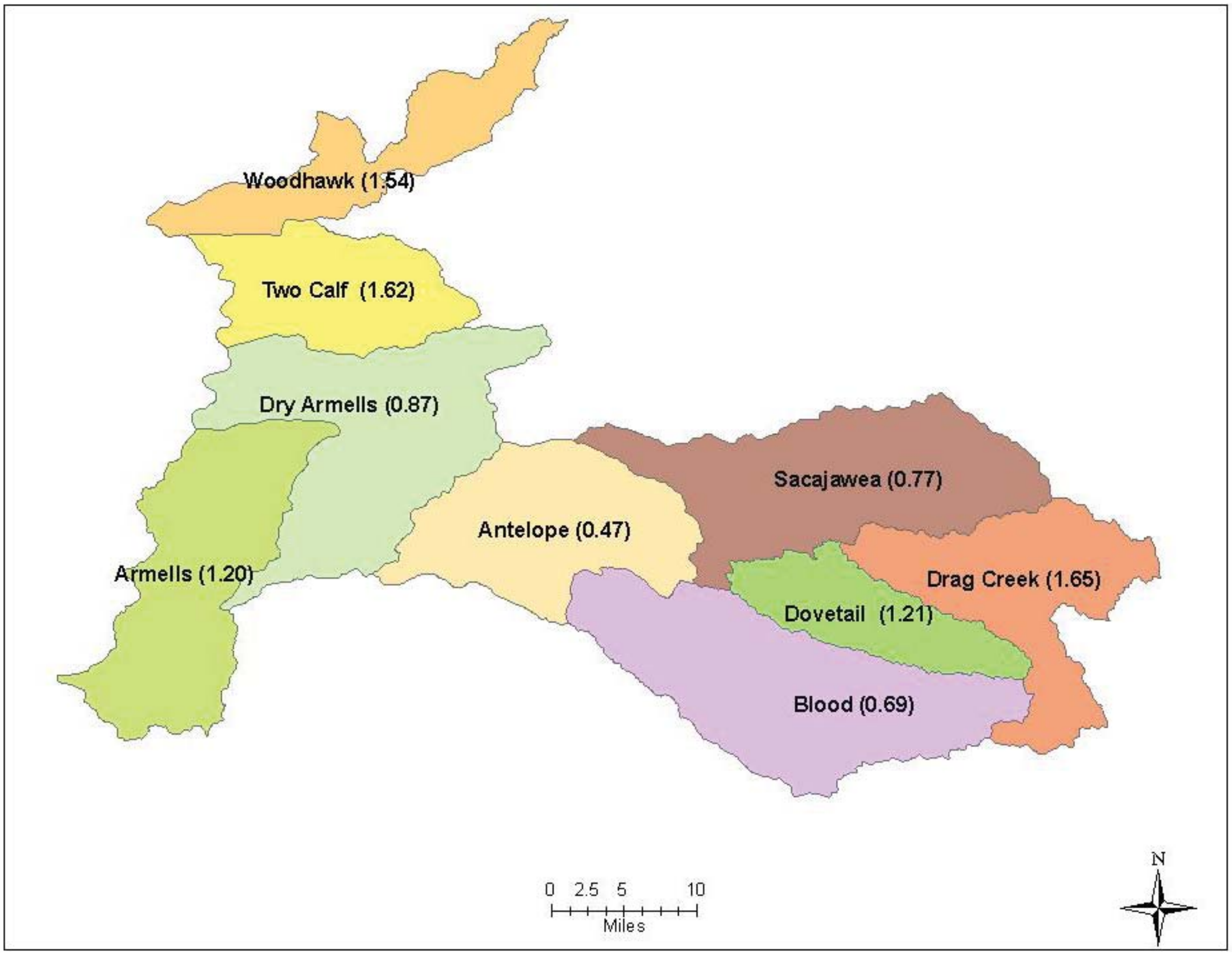

Figure 19. Composite Watershed Condition Index across 5th-code HUCs

productive gas layer, and substantial exploration and development is occurring just to the west and south of the study area. We would note, therefore, that these four watersheds are likely to be most threatened by activities associated with oil and gas development.

In this section, we examine two threats to watershed integrity that will continue regardless of energy development, grazing and noxious weeds. These are in the category of cumulative impact threats, i.e. conditions that are ongoing and that tend to have increased effects over time. These threats are by no means an exhaustive list of future possibilities --development and recreational pressures might be greater threats, if oil and gas development brings population influxes-- but they offer some insight into the susceptibility of the individual watersheds to future change.

Riparian Grazing Threat Index (I_{GT})

Cattle grazing can cause soil compaction, nutrient enrichment, vegetation trampling and removal, habitat disturbance, and, depending on the season and intensity of use, reproductive failure for both plants and animals. In riparian areas, grazing can cause stream bank destabilization, loss of riparian shade, and increased sediment and nutrient loads (George et al. 2002). To assess this threat, we used the same 50-meter buffers, but here we measured the percentage of buffers either under public land ownership (assumed to be available for grazing) or private but listed in cadastral records as having grazing as a primary use. These buffers are narrow to capture the most intense riparian grazing effects (bank collapse, loss of vegetation filtering function, etc) and to allow a cross-comparison with the Riparian Loss Index.

The Riparian Grazing Threat Index was then calculated as:

$I_{GT} = A_{RG}/A_{RT}$,

where A_{RG} is the area of public and private grazing land in the stream buffers and A_{RT} is the total buffer area, in acres.

Table 12 has a breakdown of scores for each of the 5th code watersheds. Two caveats are in order here. First, the scores represent a potential threat that may or may not be realized. For example, riparian areas in the Woodhawk watershed, which has the highest score on this metric, are not necessarily in worse condition than any other 5th code watershed; management practices may limit riparian grazing, and the land itself may be unsuitable for grazing. This index only measures potential riparian grazing land, and because the riparian corridors in this watershed are predominantly owned and managed by public agencies, a (potentially) disproportionate percentage of land is considered to be available for grazing. Management practices and stocking rates will determine actual condition. Second, low scores only indicate potential grazing threats, not impacts that may have already occurred. The Antelope Creek watershed, for example, has a low score on this index, but a high score on the Riparian Loss Index. Taken together, these scores indicate that other land use activities (roads, non-grazing agriculture, etc) may exert a greater influence on riparian vegetation than grazing. In short, this index merely represents the percentage of the riparian buffer where grazing may occur, and as such provides a flag for management planning.

Table 12. Riparian Grazing Threat Index scores

Watershed		Score
Woodhawk		0.95
Armells		0.93
Sacajawea		0.91
Dry Armells		0.91
Blood		0.90
Dovetaill		0.88
Two Calf		0.83
Antelope		0.82
Drag		0.70

<u>Noxious weeds threat index (I_{NWT})</u>

Russian knapweed (*Centaurea repens* L.), Spotted knapweed (*Centaurea maculosa*), and Leafy spurge (*Euphorbia esula*) are all present throughout the watersheds, especially in and around floodplains and riparian areas. All three pose threats to plant and wildlife diversity, aquatic integrity, and agricultural production (Pokorny and Sheley 2003). These plants spread easily during high water flows and along roadways, and establish themselves rapidly on bare or disturbed ground. Spotted knapweed is especially invasive in grasslands dominated by native bunchgrasses.

While noxious weeds pose a threat to both uplands and riparian areas, displacement of native plants in riparian areas has specific impacts on aquatic health through erosion and sedimentation. We did not distinguish between the threat posed by noxious weeds in riparian areas and uplands, but simply calculated the index as:

$I_{NWT} = PLSS_W / PLSS_W$,

where $PLSS_W$ = the number of public land survey sections where noxious weeds have been found and $PLSS_W$ = the total area of susceptible land cover classes in the watershed.

The scores for each 5th code watershed are shown in Table 13. The Drag Creek watershed ranks highest on this metric, with a score of 0.19, while Antelope Creek ranks lowest with a score of 0.00 (there are no reported public land survey sections with noxious weeds). The high score for Drag Creek reflects the concentration of noxious weeds in the broad Musselshell floodplain, particularly in the moist areas where high water from Fort Peck Reservoir overflows (See Figure 20). The low score for the Antelope Creek watershed is likely to be a result of landowner and county weed control actions, plus a relative absence of flowing water. We did not distinguish between sections

with susceptible vegetation (woody and herbaceous wetlands, grasslands and deciduous forests) and those with less susceptible vegetation (shrubland and conifer forests); if we had, scores would probably be even higher for all but the Antelope,

Table 13. Noxious Weed Threat Index scores

Watershed		Score		Weed sp.
Drag		0.19		LS,SK
Sacajawea		0.13		LS, RK
Woodhawk		0.11		LS, RK, SK
Blood		0.05		RK
Armells		0.04		SK
Two Calf		0.03		LS, RK,
Dry Armells		0.01		SK
Dovetail		0.01		SK
Antelope		0.00		

Figure 20 . Musselshell floodplain near Fort Peck

Armells, Blood, and Dry Armells watersheds (Figure 21).

These scores are generally low and indicate noxious weeds are not widespread in the subbasin. However, two cautionary notes are appropriate here. First, this index does not include all noxious

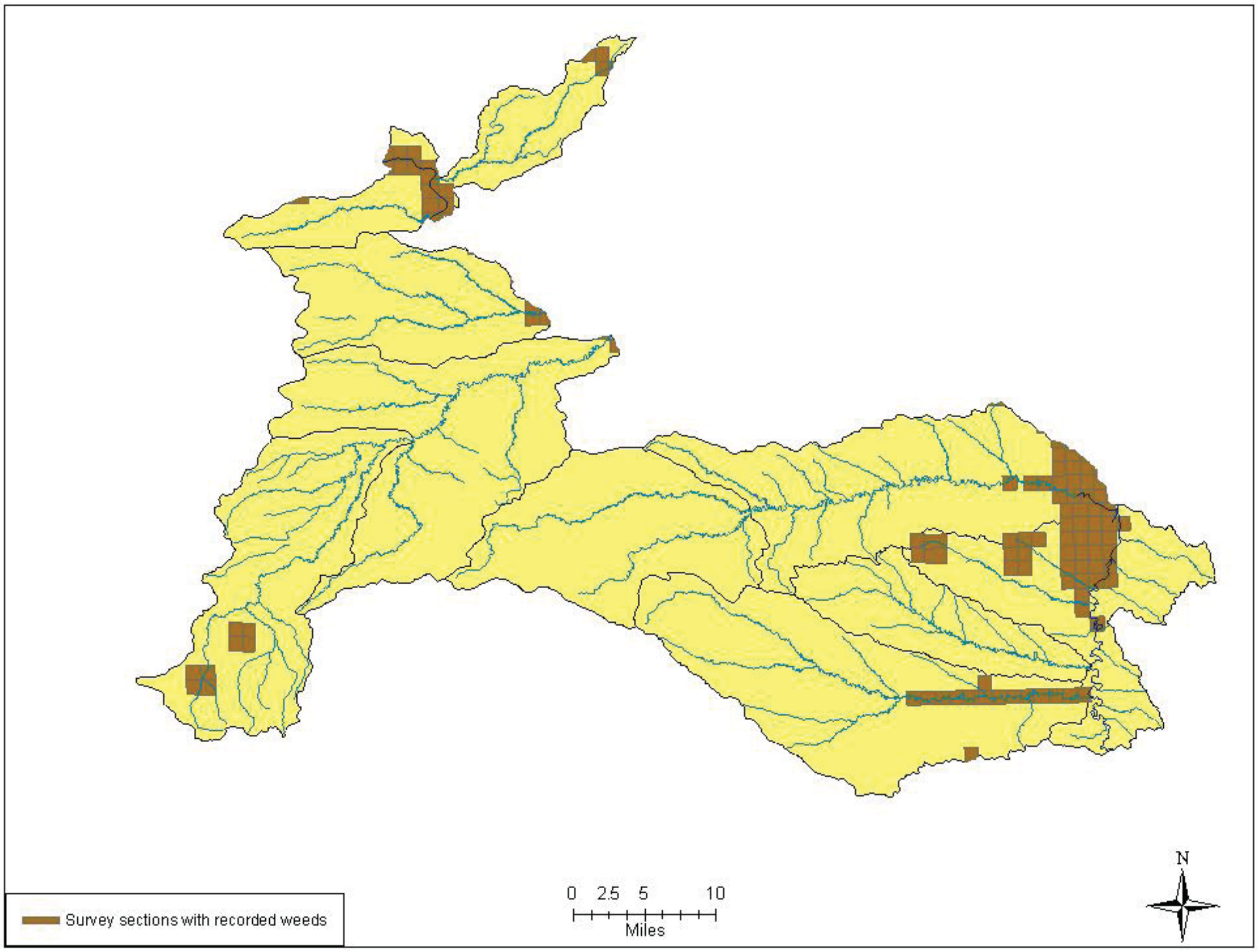

Figure 21. Public land survey sections with noxious weeds

weeds, and particularly omits Russian olive (*Elaeagnus angustifolia*) and salt cedar (*Tamarix* spp.). Russian olive is widespread along the Missouri (Kudray et al. 2004) and has been planted in several riparian corridors in the interior of the study area. Salt cedar is particularly problematic along the Musselshell and sections of the Missouri near Fort Peck dam (Pearce and Smith 2003). Second, although noxious weeds are not widespread in the nine watersheds, exotic grasses are. Smooth brome is especially common in and around riparian areas, and the grasslands host numerous introduced grass species like timothy, Japanese brome (*Bromus japonicus*) Kentucky bluegrass (*Poa pratensis*), yellow sweetclover (*Melliotus officianalis*), and cheatgrass (*Bromus tectorum*).

Composite Threat Index (CTI)

The Composite Threat Index is a simple sum of the two sub-indices, with the maximum possible score being 2.0, indicating a high degree of threats:

$$CTI = I_{GT} + I_{NWT} + IPAT$$

Table 14 shows the results for individual watersheds. Overall, these scores are not extremely high. The Woodhawk and Sacajawea watersheds both rank near the top of the list because of the high percentage of public land available for grazing, and because of the presence of noxious weeds. We would note here that if invasive woody species (e.g. salt cedar) were included, the Two Calf and Dovetail watersheds would have higher scores than they do.

Table 14. Composite Threat Index scores

Watershed		Score
Woodhawk		1.06
Sacajawea		1.04
Armells		0.97
Blood		0.95
Dry Armells		0.92
Drag		0.89
Dovetail		0.89
Two Calf		0.86
Antelope		0.82

As we noted above, we had no hard data allowing us to quantify the susceptibility of individual watersheds to impacts from oil and gas development. However, we think it is reasonable to assume that given their proximity to existing leases, the Woodhawk, Two Calf, Dry Armells and Armells Creek watersheds are most likely to see such development in the future. Associated residential and commercial development would probably have the greatest impacts in watersheds closest to existing services (Armells, Dry Armells, and Two Calf), although recreational pressures would likely be felt most in areas with substantial public ownership and access to the Missouri (Two Calf and Woodhawk) or to good hunting opportunities (Sacajawea, Dovetail, Drag).

We also were not able to quantify threats related to fire, although we observed wildland fire activity in both the Drag and Sacajawea Creek watersheds in July and August of 2006 (Figure 22). During field surveys, we also observed evidence of declining forest health in the Judith Mountain area, with fire and insects both posing a danger.

Figure 22. Dog Creek Fire

Interpreting the Broad-scale Assessment Composite Indices

Although it may be tempting to continue to reduce the composite assessment indices to a single number, we have chosen to keep them separate

because we think each represents a distinct and important piece of information in the watershed assessment. The Composite Natural Complexity Index provides a basis for assessing the raw material, i.e. the range of natural variability within the individual watersheds, which can be used as a surrogate for natural or background conditions. The Composite Watershed Condition Index provides an overview of the magnitude of change from natural conditions, allowing us to compare individual watersheds and tease out factors, like stream corridor land use patterns or road density, that exert measurable influence on overall condition. The Composite Threat Index is a measure of what can still be lost. This index should be interpreted on its own, or at most in relation to the Composite Watershed Condition Index. For example, the Woodhawk watershed ranks fairly high on the Composite Watershed Condition Index, and has a high Threat Index score because of the potential risk posed by grazing of public land in riparian corridors. This could be an early warning that grazing management plans and oversight should focus on the riparian resource. However, only on-site investigation can fully determine the extent of vulnerability.

Fine-scale Assessments

During the summer of 2006, MTNHP ecologists surveyed wetlands, ponds and some streams, conducting Proper Functioning Condition assessments at 43 sites and detailed aquatic surveys at seven lotic, seven lentic, and one mountain spring site.

Wetland Assessments

Of the 43 wetlands assessed, seven were found to be in proper functioning condition, seven were not functioning, and the remainder were functioning at risk. Most (20) of the wetlands functioning at risk were stable; three exhibited an upward trend and four exhibited a downward trend.

The patchwork of land ownership throughout the study area makes it difficult to determine with complete certainty whether individual surveyed wetlands are on BLM, private, or other public land, but it appears from cadastral and stewardship databases that 16 of the 43 wetlands are on BLM lands. Of these 16, one is in proper functioning condition, three are not functioning, two are functioning with a downward trend, and the remainder are functioning at risk but stable (Figures 23-26). With continued management, the trend on the stable wetlands should be upward. Given the percentage of BLM ownership in the study area, these proportions suggest BLM-managed wetlands are in no better or worse condition than other wetlands.

Appendices A and B include the individual PFC score breakdowns and the comments for each surveyed wetland. The three non-functioning wetlands all lacked wetland vegetation. Two were heavily impacted by cattle activity; the third appeared to have been recently excavated. Across the study area, the high percentage of wetlands determined to be functioning at risk is attributable to their origin and purpose: most were established as reservoirs or stock ponds, or were artifacts of road construction, when high berms and inappropriate culverts resulted in semi-permanent ponds. Road-origin wetlands typically occur on the upstream side of the roads, and depending on the height of the berm and the size of the culvert, are often heavily vegetated. However, some have formed in depressions created water when drops downstream from shotgun culverts. Because stock ponds, reservoirs and road-berm wetlands are all dependent on human initiative to maintain them, we considered them all to be functioning at risk, even though most have vegetation typical of shallow, aquatic bed, semi-permanently flooded depressional wetlands in the western Great Plains. Recognizing that the purpose of stock ponds and reservoirs is generally associated with livestock rearing, we did not necessarily assign a downward trend finding to our summary determinations unless cattle use was clearly leading to bank damage or broad vegetation loss.

While it appears that wetlands rated as non-functioning or functioning at risk/downward are disproportionately clustered in the Sacajawea and Blood Creek watersheds, we caution that these surveys were not conducted within a statistically valid sample design: we located wetlands from

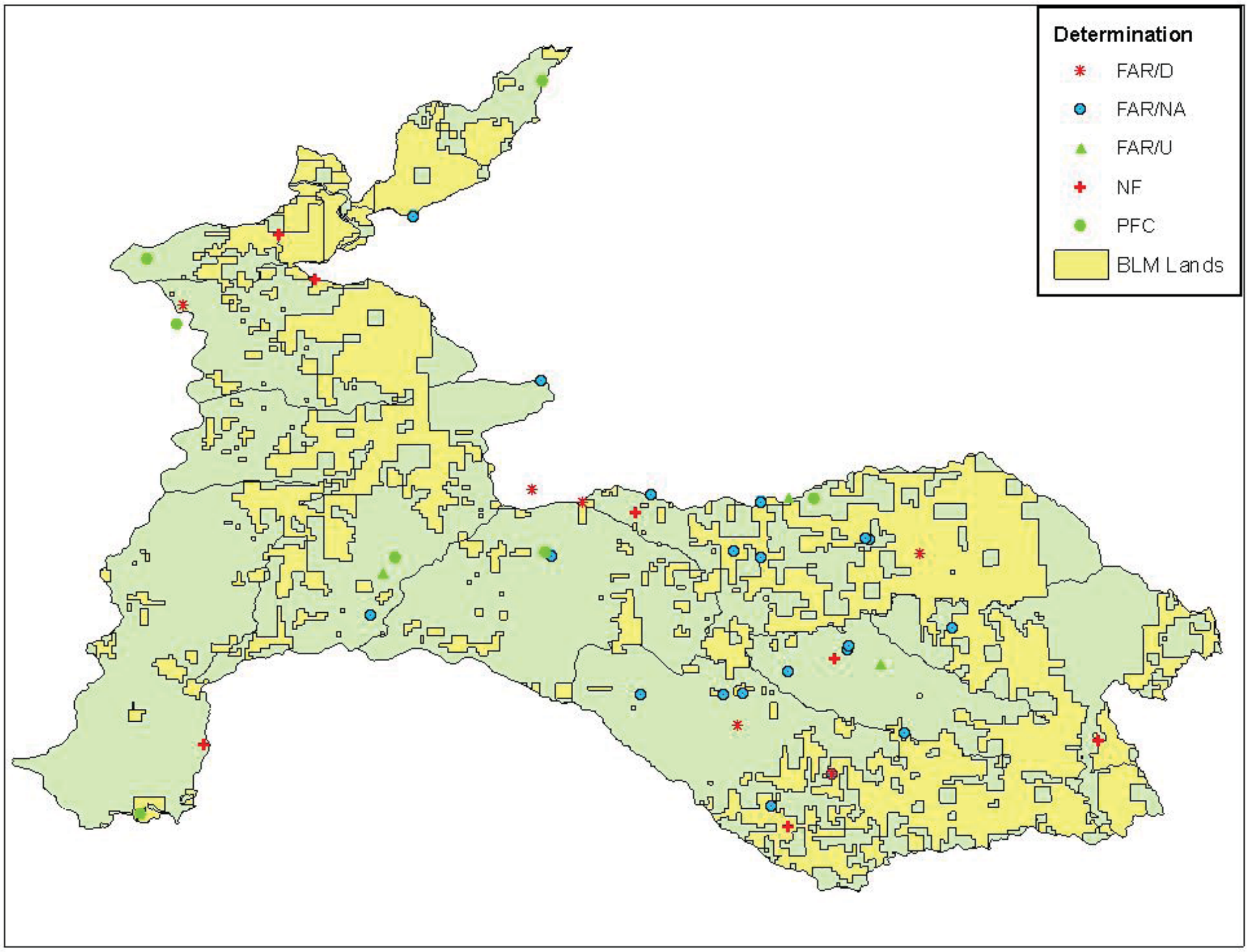

Figure 23. Proper Functioning Condition (PFC) results

Figure 24. A proper functioning condition wetland near Judith Mountain

Figure 25. A stable but functioning at risk wetland

Figure 26. A non-functioning wetland near Blood Creek

aerial photos, and chose survey sites either on public land or accessible for survey purposes from public roadways. While it is entirely possible that wetland condition in these two watersheds is generally worse than in other watersheds, that would have to be determined from more systematic sampling.

Fish and Macroinvertebrate Assessments

As a second component of our fine-scale assessment work, we surveyed and assessed aquatic community integrity based on macroinvertebrate, fish and habitat sampling. Our goal was to identify and interpret key community indicators using standardized protocols and biotic thresholds, and to compare these against reference condition standards at the watershed-level and local-reach scale.

We completed riparian habitat assessments, measured water quality parameters, and surveyed fish and macroinvertebrates for seven lotic prairie sites, one mountain spring-influenced site and seven lentic (reservoir-ponded) sites. Four of the seven lotic sites supported fish, and all had macroinvertebrates. Eight other stream sites were dry.

Two streams in the Crooked and Armells Creek watersheds were evaluated along a longitudinal sequence using additional biological data from Montana Fish, Wildlife and Parks (MTFWP) and the Montana Department of Environmental Quality (MTDEQ). Biological community integrity was calculated at all sites using Fish Integrated Biotic Indices (IBI's) and Observed/Expected Models (O/E) (Stagliano 2005), as well as macroinvertebrate multi-metrics (Bramblett et al. 2005). Summary descriptions of sites based on the overall community integrity and site observations are included in Table 1 and 2 of Appendix C. Results of the community integrity assessments are described below.

Habitat Evaluations

For the streams surveyed in 2006, the highest scores using both EPA Rapid Bioassessment Protocol (RBP) (Barbour et al. 1999) and BLM habitat assessment methods were measured in the Sacajawea River watershed. Sacajawea sites #1 and 2 had good site conditions for a Great Plains Prairie Stream, with EPA RBP scores of 162 and 159, respectively. The analysis of conductivity and turbidity collected byour surveys and in earlier MTFWP and MTDEQ surveys showed that both conductivity and turbidity increased at the downstream reaches of a stream longitudinal series. Conductivity values at both sites on Armells Creek were above state thresholds for impairment.

Fish Communities

Overall, six fish species (five native/one introduced) were identified from collections of 1,419 individuals at the lotic sites visited in 2006 (Table 3, Appendix C). Previous fish data collected by MTFWP from other sites within these streams increased the total species count to 18. Average fish species richness per site in 2006 was five; the most diverse site was the Sacajawea downstream reach with six species (5 native).

During 2006 sampling, fathead minnows (*Pimephales promelas*), lake chubs (*Couesius plumbeus*) and sand shiners (*Notropis stramineus*) were collected at all (100%) of our survey sites where fish were present. Using Montana's Prairie Fish IBI, one of the four sites ranked non-impaired (good to excellent biological integrity), two were slightly impaired (moderate integrity) and one was moderately impaired (poor biotic integrity). Two sites (Two Calf and Blood Creek) were ranked

severely impaired based on Fish IBI or O/E score because fish were expected but not found, resulting in scores of zero. No fish were found at the lentic sites.

Macroinvertebrate Communities

Overall, 101 macroinvertebrate taxa were reported from the assessment sites [same as surveyed sites?]. Average macroinvertebrate taxa richness per site was 22 and the highest reported at a single site was 36 taxa. Using the Montana Department of Environmental Quality macroinvertebrate multimetric index (MMI, Jessup et al. 2005, Feldman 2006), nine of the 18 sites were ranked non-impaired (good to excellent biological integrity), six were slightly impaired and three were moderately impaired. Most stream sites containing riffle areas scored much higher on the MMI than sites with exclusively pool areas. Sites visited in the Sacajawea watershed rankd higher in macroinvertebrate richness?/integrity? than those in the Armells watershed.

Dragonflies and Damselflies

We recorded incidental dragonfly and damselfly observations during the fish and macroinvertebrate surveys. Four dragonfly species were common across most lentic sites: common green darner (Anax junius), common whitetail (*Libelulla lydia*), eight-spotted skimmer (*Libellula forensic*), and variagated meadowhawk (*Sympetrium corruptum*). No Species of Concern were noted at any sites. The pale snaketail (*Ophiogomphus severus*) was noted only on the mainstem Missouri River near? the confluence of Bull and Woodhawk Creek tributaries. Common damselflies at most sites included the familiar bluet (*Enallagma civile*), northern bluet (*Enallagma cyathigerum*), eastern forktail (*Ischnura verticalis*) and the common spreadwing (*Lestes disjunctus*). We observed a linear relationship (r2=84.27) between the number of aquatic plant species and the number of dragonfly and damselfly species at any given site.

Amphibians and Reptiles

We recorded incidental herpetofauna observations made during fish and macroinvertebrate surveys. Five amphibian species were documented, including Woodhouse's toad (*Bufo woodhousei*), Great Plains toad (*Bufo cognatus*), Plains spadefoot (*Spea bombifrons*), tiger salamander (*Ambystoma tigrinum*) and the northern leopard frog (*Rana pipiens*);. We also observed one reptile species, the Plains garter snake (*Thamnophis radix*). Tiger salamanders had the highest site occupancy rate at the lentic sites (57%) [compared to other species or other sites?] and were seined in 2 fishless prairie streams. Table 4 in Appendix C lists these species.

Overall, these results indicate that aquatic habitat in the study area watersheds is well below optimal, mostly as a result of stream dewatering. Sites where we found fish ranked low on biotic indices, and most sites we visited had no water at all.

Relationship Between Broad-scale and Fine-scale Assessments

It is useful to distinguish between cumulative impacts and cumulative effects (Johnson 2005). Broad-scale assessments look at impacts, i.e. the activities and events changing natural conditions, while fine-scale assessments examine the results of those impacts. In the study area, water diversions and impoundments are impacts, while dewatered streams, non-functioning wetlands or loss of species are effects. Impacts may occur at a significance distance from their effects, as is often the case with upstream-downstream relationships observed in aquatic systems, or they may occur in close proximity. For example, impacts from land use activities in upstream watersheds may have effects downstream, with the biological integrity of a given aquatic survey being characterized as "impaired." On the other hand, the higher population density, greater percentage of agricultural use, and increased movement of machinery associated with crop agriculture may lead to a relatively localized spread of noxious weeds and exotic species.

The value of watershed-level assessments lies in identifying areas where impacts are currently occurring, rather than merely seeking out effects that have already occurred. By combining both site-level and watershed-level assessments, it is possible to select areas where management can make a substantial difference in future wetland and

aquatic health. Thus, even when there are similar findings between the two levels of assessment, they need to be examined less for correlation than for the different perspectives they provide.

Our fine scale assessments did not give us any greater insight into conditions in the study area watersheds than did the broad-scale assessments. The absence of perennial streams, while attributable in part to human activities, is an area-wide impact with effects on all aquatic systems and individual aquatic features. What fine-scale assessments can offer, however, is guidance to management. Some specific management opportunities are discussed in the final section.

Management Opportunities

The BLM owns and administers a substantial proportion of land within the study area, and can play an important role in conserving and restoring natural watershed functions. Based on our broad-scale and fine-scale assessments, and our observations in the field, we have identified several specific management opportunities.

Invasive Species

Many of the exotic species we observed are not considered noxious (e.g. smooth and Japanese brome, yellow sweetclover, crested wheatgrass). However, we did see several stands of knapweed near reservoirs and along roadsides, and Russian olive was common, especially in the eastern portion of the study area around Blood Creek and the Musselshell River. As noted earlier, the Missouri River has also been invaded by salt cedar. Russian olive and salt cedar can dominate riparian woody vegetation with potentially dire consequences for habitat quality. While salt cedar infestation is driven in part by upstream activities, vigilant monitoring by BLM staff, permittees and leaseholders may still prevent its spread. In general, there is a good opportunity for preventing the spread of weeds into weed-free parts of the watershed, which will minimize weed-driven loss of range forage and riparian plant communities.

Grazing Management

Although several reservoirs and stock ponds have been negatively impacted by grazing, our field surveys indicated rangelands across the study area are in generally good condition, and reflect good grazing management. However, riparian vegetation represents an especially attractive resource for cattle and sheep, and the shade that riparian trees provide is a magnet during hot summer days. We do not think flows within the study area will ever be sufficient to reestablish cottonwoods, and we expect the remnant cottonwoods around reservoirs and steams will soon die out, reducing attractiveness to cattle. Thus, habitat quality would be best maintained if managers avoided replanting trees around reservoir edges. We also suggest supplements and insect dusters be placed away from reservoir edges to discourage cattle from congregating, and additional off-reservoir watering opportunities be provided to minimize impacts. [I think this is obvious enough not to need reiteration.]These management practices, coupled with frequent utilization monitoring and the use of physical barriers where necessary will help give impaired habitats the opportunity to recover.

Watershed-specific Management Efforts

The Woodhawk-Bull Creek watershed currently has an 8,000-plus acre wilderness study area, and as we noted earlier, most of its riparian areas are under BLM ownership or management. This offersan excellent opportunity for concentrated management efforts both within the wilderness study area and on upstream lands.

Drag Creek, while having less diversity than some of the other watersheds, also has some of the best quality habitat. Because of its relative isolation and inaccessibility, there is a good opportunity for management to retain its natural state. We noted during our field surveys off-road vehicles had broken many new roads following the 2006 fires, and road closure signs were generally being ignored, suggesting this watershed would benefit from additional enforcement efforts, especially during big game hunting season.

Because of their good condition and habitat quality, the Woodhawk-Bull Creek and Drag Creek watershed offer excellent opportunities for monitoring and management to maintain existing values. While all the watersheds can benefit from careful management, protecting of the healthiest watersheds is a highly cost-effective way of maintaining ecological and habitat values.

Conservation of Aquatic Resources

Results of our site-specific assessments indicate a need to address grazing pressures on Jakes Reservoir and the south end of Dry Blood

Reservoir (two non-functioning sites). Other reservoirs and ponds with non-functioning or functioning at risk/downward determinations are also prime targets for management. Another opportunity to protect better-quality aquatic habitat is at the high-quality mountain spring below the saddle of Judith and Red Mountains. While the spring itself is in good condition, culverts and ditches downstream are failing, leading to gullying, erosion, and loss of water to streams.

Finally, we again note that one of the most significant future risks to habitat qualitiy in this areas is population growth and associated changes related to oil and gas development, which may place unforeseen pressures on public land resources, especially in areas where aquatic recreation opportunities are limited. The dissected topography of the Missouri and Musselshell breaks are attractive hunting and off-roading lands, and the relatively light pressures experienced now could grow exponentially in coming years. Since intermittent streambeds often attract off-road use, pro-active monitoring and management in these areas may greatly reduce the potential for serious habitat damage.

Literature Cited

Barbour, M., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. United States Environmental Protection Agency; Office of Water: Washington, D.C

Berkas, W.R., M.K. White, P.B. Ladd, F.A. Bailey, and K.A. Dodge. 2004. Montana Water Resources Data 2004. Water Data Report MT-04-1 and MT-04-2.

BLM 1992. Judith Valley Phillips Resource Management Plan and Environmental Impact Statement. BLM-MT-93-001-4410

BLM 2005. Upper Missouri River Breaks National Monument. Draft Resource Management Plan and Environmental Impact Statement. BLM/MT/PL-05/014+1610

BLM 2006. Environmental Assessment. Forest Health and Vegetation Management for the Judith and Moccasin Mountains. EA # MT-060-02-01.

Bovee, K.D., and M.L. Scott. 2002. Implications of flood pulse restoration for populus regeneration on the upper Missouri River. River Research and Applications 18: 287-298.

Bramblett, R. G., T. R. Johnson, A. V. Zale, A. V., and D. Heggem. 2005. Development and Evaluation of a Fish Assemblage Index of Biotic Integrity for Northwestern Great Plains. Transactions of the American Fisheries Society 134:624–640, 2005.

Castelle, A. J., A. W. Johnson and C. Conolly. 1994. Wetland and stream buffer size requirements– a review. Journal of Environmental Quality 23: 878-882.

Cowardin L.M., V. Carter, F.C. Golet and E.T LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. USFWS, Office of Biol. Ser. (FWS/OBS-79/31), December 1979. 103 pp.

Crowe, E.C. and G. Kudray. 2003. Wetland Assessment of the Whitewater Watershed. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 106 pp.

DEQ. 2001. Lower Musselshell TMDL Planning Area Decision Document. Montana Department of Environmental Quality, Helena, MT. 15pp.

DeVoto, B. (ed). 1997. The Journals of Lewis and Clark. Seattle, WA. Mariner Books. 576 pp.

Dorn, R. D. 1984. Vascular Plants of Montana. Mountain West Publishing, Cheyenne, WY. 276 pp.

Feldman, D. 2006. Interpretation of New Macroinvertebrate Models by WQPB. Draft Report. Montana Department of Environmental Quality, Planning Prevention and Assistance Division, Water Quality Planning Bureau, Water Quality Standards Section. 1520 E. 6th Avenue, Helena, MT 59620. 14 pp.

Furniss, M.J., T.D. Roeloffs, and C.S. Yee. 1991. Road construction and maintenance. Pages 297-323 in W.R. Meehan, Editor. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. Special Publication 19. American Fisheries Society, Bethesda, Maryland.

George, M.R., R.E. Larsen, N.K. McDougald, K.W. Tate, J.D. Gerlach, Jr., and K.O. Fulgham. 2002. Influence of grazing on channel morphology of intermittent streams. J. Range Management. 55:551-557.

Great Plains Flora Association. 1986. Flora of the Great Plains. Lawrence, KS. University Press of Kansas. 1400 pp.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the United States. Volume I. The national vegetation classification system: development, status, and applications. The Nature Conservancy, Arlington, Virginia. USA. 126 pp.

Hauer, F. R., B. J. Cook, M. C. Gilbert, E. C. Clairain, Jr., and R. D. Smith. 2001. The Hydrogeomorphic Approach to Functional Assessment: A Regional Guidebook for Assessing the Functions of Riverine Floodplain Wetlands in the Northern Rocky Mountains. Special Publ. WES, USCOE, Vicksburg, MS. 255 pp.

Hauer, F. R., B. J. Cook, M. C. Gilbert, E. C. Clairain, Jr., and R. D. Smith. May 2002. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Intermontane Prairie Pothole Wetlands in the Northern Rocky Mountains. Special Publication ERDC/EL TR-02-7. WES, USCOE, Vicksburg, MS. 118 pp. plus appendices.

Jessup, B., J. Stribling, and C. Hawkins. 2005. Biological indicators of stream condition in Montana using macroinvertebrates. Tetra Tech, Inc. November 2005 (draft).

Johnson, J.B. 2005. Hydrogeomorphic wetland profiling: An approach to landscape and cumulative impacts analysis. EPA/620/R-05/001. U.S. Environmental Protection Agency, Washington, DC.

Kartesz, J. T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. *In* J. T. Kartesz and C. A. Meacham, editors. Synthesis of the North American flora, version 1.0. North Carolina Botanical Garden, Chapel Hill, North Carolina.

Kudray, G., P. Hendricks, E. Crowe and S. Cooper. 2004. Riparian Forests of the Wild and Scenic Missouri River: Ecology and Management. Report to the Lewistown Field Office, Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 29 pp. plus appendices.

McCarthy, P.M. 2005. Statistical summaries of streamflow in Montana and adjacent areas, water years 1900 through 2002. U.S. Geological Survey Scientific Investigations Report 2004-5266, 317 pp.

Moyle, P.B. and M.P. Marchetti. 1999. Applications of indices of biotic integrity to California streams and watersheds. Pages 367-382 in T.P. Simon, editor. Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press, Boca Raton, FL. 671 pp.

National Agricultural Statistics Service, 207. Data available from http://www.nass.usda.gov. Accessed on February 20, 2007.

Pearce, C.M., and D.G. Smith. 2003. Saltcedar: distribution, abundance, and dispersal mechanisms, northern Montana, USA: Wetlands, v. 23, no. 2, p. 215–228

Pokorny, M. and R. Sheley. 2003. Montana's noxious weeds (Rev. ed). Montana State University, Bozeman, MT. Publication EB-159.

Power, M.E. G. Parker, W.E. Dietrich, and A. Sun. 1995. How does floodplain width affect floodplain river ecology? A preliminary exploration using simulations. Geomorphology 13: 301-317

Pritchard, D., F. Berg, W. Hagenbuck, R. Krapf, R. Leinard, S. Leonard, M. Manning, C. Noble and J. Staats. 1999. Riparian Area Management: a user guide to assessing proper functioning condition and the supporting science for lentic areas. TR 1737-16. Bureau of Land Management, BLM/RS/ST-99/001+1737, National Applied Resource Sciences Center, CO.

Sahni. A. 1972. The vertebrate fauna of the Judith River Formation, Montana. Bulletin of the American Natural History Foundation, Vol. 147, article 6.

Scott, M.L., G.T. Auble and J.M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological Applications 7 (2): 677-690.

Stagliano, David, M. 2005. Aquatic Community Classification and Ecosystem Diversity in Montana's Missouri River Watershed. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana. 65 pp. plus appendices.

Tiner, R., M. Starr, H. Bergquist, and J. Swords. 2000. Watershed-based wetland characterization for Maryland's Nanticoke River and Coastal Bays watersheds: A preliminary assessment report. U.S. Fish & Wildlife Service, National Wetlands Inventory (NWI) Program, Northeast Region, Hadley, MA. Prepared for the Maryland Department of Natural Resources, Coastal Zone Management Program (pursuant to National Oceanic and Atmospheric Administration award). NWI technical report.

Vance, L.K. 2005. Watershed assessment of the Cottonwood and Whitewater watersheds. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 57 pp. plus appendices.

Vance, L.., D. Stagliano, and G. M. Kudray. 2006. Watershed Assessment of the Middle Powder Subbasin, Montana. A report to the Bureau of Land Management, Montana State Office. Montana Natural Heritage Program, Helena, Montana. 61 pp. plus appendices

Western Regional Climate Center 2007. Data available from http://www.wrcc.dri.edu. Accessed on January 23, 2007.

Wilkin D.C. and S.J. Hebel. 1982. Erosion, redeposition and delivery of sediment to mid- western streams. Water Resour. Res., 18:1278-1282.

Woods, A.J., J.M. Omernik, J.A. Nesser, J. Shelden, and S.H. Azevedo. 1999. Ecoregions of Montana. (2 sided, 2 sheet color poster with map, descriptive text, summary tables, and photographs). U.S. Geological Survey, Reston, VA. Scale 1:1,500,000.

Appendix A. PFC Ratings

		Site	
Hydrology	L-06-01	L-06-02	L-06-03
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	N	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	N	N	Y
5) Water quality is sufficient to support riparian-wetland plants	N	Y	N
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	Y	N	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	N	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	N	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	N	Y
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	N	Y	N
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	N
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	N	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/NA	FAR/NA	FAR/UP

		Site	
Hydrology	L-06-04	L-06-05	L-06-06
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	Y	N	y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	N	N	Y
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	Y	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	N	N
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/NA	FAR/UP	FAR/UP

		Site	
Hydrology	L-06-07	L-06-08	L-06-09
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	Y	N	Y
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance			
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)	N	N	Y
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	Y	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	N	Y
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/UP	FAR/NA	PFC

		Site	
Hydrology	L-06-10	L-06-11	L-06-12
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	N	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	N	Y	Y
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	Y
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	Y	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N	N	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	N	N	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	N	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	Y	Y
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	N	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	NF	FAR/NA	PFC

		Site	
Hydrology	L-06-13	L-06-14	L-06-15
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	Y	N
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	Y	Y	N
5) Water quality is sufficient to support riparian-wetland plants	N	Y	N
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	Y	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	N	Y	N
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	N	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	N	Y	N
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	Y	N
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)			
is sufficent to compose and maintain hydric soils	Y	Y	Y
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	N	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	N
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	NF	PFC	FAR/D

		Site	
Hydrology	L-06-16	L-06-17	L-06-18
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	N	Y	Y
5) Water quality is sufficient to support riparian-wetland plants	N	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	Y	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	Y	Y	N
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	N	Y	N
10) Species present indicate maintenance of riparian-wetland soil moisture	N	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	N	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	Y	Y
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)			
is sufficent to compose and maintain hydric soils	Y	Y	N
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	N	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	NF	PFC	FAR/NA

		Site	
Hydrology	L-06-19	L-06-20	L-06-21
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	Y	N
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	N
4. Upland watershed is not contributing to riparian-wetland degradation	N	N	N
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	Y	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N	Y	N
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	N
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	N	N
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	N	N
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	N	Y	N
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	N	N	N
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/D	FAR/UP	NF

		Site	
Hydrology	L-06-22	L-06-23	L-06-24
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive			
3) Riparian-wetland area is enlarging or has achieved potential	Y	N	N
4. Upland watershed is not contributing to riparian-wetland degradation			
5) Water quality is sufficient to support riparian-wetland plants	N	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N	N	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	N	Y	N
10) Species present indicate maintenance of riparian-wetland soil moisture	N	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	N	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	N	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	N	N	N
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	N	N
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	N	Y	N
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	N	N	N
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	NF	FAR/D	FAR/NA

		Site	
Hydrology	L-06-25	L-06-26	L-06-27
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	N	Y	N
5) Water quality is sufficient to support riparian-wetland plants	N	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	Y	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	N	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	N	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	N	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	N	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	N	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	Y	Y
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	N	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	N	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	NF	FAR/U	FAR/NA

		Site	
Hydrology	L-06-28	L-06-29	L-06-30
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	N	N	N
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	Y	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	Y	N
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N	Y	N
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/NA	FAR/UP	FAR/D

		Site	
Hydrology	L-06-31	L-06-32	L-06-33
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	Y	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	Y	Y	N
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	Y	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	Y	N
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	N
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	Y	Y	N
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/UP	FAR/D	FAR/D

		Site	
Hydrology	L-06-34	L-06-35	L-06-36
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	Y	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	N	N	Y
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	Y
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	Y	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	Y	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	Y	N	Y
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/NA	FAR/UP	PFC

		Site	
Hydrology	L-06-37	L-06-38	L-06-39
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	Y	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	Y	N	N
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	N
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	Y	Y	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	Y	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	N	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	N	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	Y	N	N
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/U	FAR/UP	PFC

		Site	
Hydrology	L-06-40	L-06-41	L-06-42
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y
or inundated in "relatively freqent" events			
2) Fluctuation of water levels is not excessive	Y	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y
4. Upland watershed is not contributing to riparian-wetland degradation	Y	Y	Y
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y
6) Natural surface or subsurface flow paterns are not altered by disturbance	N	N	Y
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N	N	Y
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	Y	Y	Y
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	Y	Y	Y
10) Species present indicate maintenance of riparian-wetland soil moisture	Y	Y	Y
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	Y	Y	Y
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	Y	Y	Y
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	Y	Y	Y
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y	Y	Y
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y	Y	Y
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y	Y	Y
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	Y	Y	Y
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	Y	Y	Y
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	FAR/U	FAR/NA	PFC

	Site		
Hydrology	L-06-43		
1) Riparian-wetland area is saturated at or near the surface	Y		
or inundated in “relatively freqent” events			
2) Fluctuation of water levels is not excessive	N		
3) Riparian-wetland area is enlarging or has achieved potential	N		
4. Upland watershed is not contributing to riparian-wetland degradation	N		
5) Water quality is sufficient to support riparian-wetland plants	N		
6) Natural surface or subsurface flow paterns are not altered by disturbance	N		
(i.e. hoof action, dams, dikes, trails, roads, rills, gullies, drilling activities)			
7) Structure accomodates safe passage of flows (e.g. no headcut affecting	N		
dam or spillway)			
Vegetation			
8) There is diverse age-class distribution of riparian-wetland (recruitment for	N		
maintenance/recovery)			
9) There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)	N		
10) Species present indicate maintenance of riparian-wetland soil moisture	Y		
characteristics			
11) Vegetation is comprised of those plants or plant communities that have root	N		
masses capable of withstanding wind events, wave flow events, or overland flows			
(e.g. storm events, snowmelt)			
12) Riparian-wetland plants exhibit high vigor	N		
13) Adequate riparian-wetland vegetative cover is present to protect shoreline/	N		
soil surface and dissipate energy during high wind and wave events or overland			
flows.			
14) Frost or abnormal hydrologic heaving is not present	Y		
15) Favorable microsite condition (i.e. woody material, water temperature, etc)	N		
is maintained by adjacent site characteristics			
Erosion/deposition			
16) Accumulation of chemicals affecting plant productivity is not apparent	Y		
17) Saturation of soils (i.e. ponding, flooding frequency, and duration)	Y		
is sufficent to compose and maintain hydric soils			
18). Underlying geologic structure/soil material/permafrost is	Y		
capable of restricting water percolation			
19) Riparian-wetland is in balance with water and sediment being	N		
supplied by the watershed (i.e. no excessive erosion or deposition)			
20) Islands and shoreline characteristics (i.e.e rocks, coarse and/or	N		
large woody material) areadequate to dissipate wind and wave event			
energies			
Summary Determination	NF		

APPENDIX B. PFC COMMENTS

SITE	CONDITION	COMMENTS (BLM SITES IN RED)
L-06-01	FAR/NA	This site is typical of excavated ponds along intermittent creeks in this watershed.
		Vegetation is characteristic of moist but not wet areas (snowberry-rose communuty)
		Kentucky bluegrass and foxtail barley are widespread, as are thistle and yellow
		sweetclover. The dam appears sound. There are a few remnant cottonwoods but
		these are in poor condition.
L-06-02	FAR/NA	This temporarily flooded wetland has formed upstream of an elevated road berm. The
		culvert appears to be too small to handle the flow, resulting in the ponding that created
		the wetland. Another berm separates this wetland from one just upstream. Pugging is
		present, but hoofprints are mostly antelope. Sedimentation is evident. Vegetation
		is typical of wet-to-moist areas, with hawthorn, snowberry, rose and licorice in the drier
		areas, and rush, and bulrush, spikerush, and cattails in the wetter portions. Canada
		thistle was present but not ubiquitous.
L-06-03	FAR/UP	This swale is characteristic of many found in the study area. An intermittent stream is
		diked downstream by a road. Foxtail barley dominates. There was some standing water
		in June.
L-06-04	FAR/NA	This is a pond/wetland area, created when the berm of the pond released enough water
		that a wetland dominated by cattail, spikerush, bulrush, sedge, and reeds formed
		downstream. The assessment refers to the downstream wetland. We considered it to be
		functioning at risk because it depends on maintenance of the berm.
L-06-05	FAR/UP	Another man-made wetland excavated near Sacajawea Creek. Uplands are greasewood.
		Spikerush and sedges dominate, with foxtail barley in drier areas. Yelow sweetclover
		and dock are common. Pugging from cattle was evident.
L-06-06	FAR/UP	This lacustrine fringe wetland is just up the drainage from L-06-05. Bulrush, spikerush
		and sedge species are found along the shoreline. Smooth brome and yellow sweetclover
		are common. Pugging and hummocking are minimal, but we saw several cattle in the
		drier portions upstream where foxtail barley is more common.
L-06-07	FAR/UP	Depression on downstream side of large culvert under road. Spikerush, tufted hairgrass,
		sedges, and sloughgrass, plus yellow sweetclover and dock. Some smartweed in the
		deeper water. Road immediately adjacent a source of dust and sediment.
L-06-08	FAR/NA	This dammed wetland has spikerush, sloughgrass, and foxtail barley along with a small
		amount of sedge. Drier areas contain yellowcress (rorippa spp.), yellow sweetclover,
		Kentucky bluegrass, crested wheat, and Canadian thistle. Uplands are sparsely
		vegetated with yellowcress.

SITE	CONDITION	COMMENTS (BLM SITES IN RED)
L-06-09	PFC	This saline site is a greasewood flat/ throughflow depression wetland with a
		characteristic vegetation community of greasewood, saltbush, saltgrass, and prairie
		sandreed, with foxtail barley and nutgrass around the margins, and big sage in the
		uplands.
L-06-10	NF	We determined this small wetland to be nonfunctional because of hydrologic
		alteration, sedimentation, disturbance from grazing, and general dewatering.
		This site is in an intermittent channel of a Sacajawea Creek tributary. The dominant
		vegetation is spikerush, club-rush (scirpus lacustris)and sloughgrass, with some
		foxtail barley, dock, and western wheatgrass.
L-06-11	FAR/NA	There are actually two wetlands here, a lacustrine fringe wetland and a palustrine
		emergent wetland formed downsteam of its dam berm by seepage. The large pond is
		fringed with spikerush with foxtail barley and yellow sweetclover occupying the
		drier margins. The downstream wetland is a cattail and bulrush-dominated marsh.
		The berm separating the two is heavily infested with saltcedar. We rated these two
		wetlands as functioning at risk because of the exotics and invasives, but primarily
		because the wetlands' existence depends on the success of the berm
L-06-12	PFC	This is a headwater wetland feeding Armells Creek just below the Judith-Red Mountain
		saddle, dominated by water birch, with speckled alder, and some red osier dogwood.
		Understory shrubs include chokecherry, serviceberry and buffaloberry. Mint, nebraska
		sedge and beaked sedge were common in wetter areas, as were several unidentified
		vascular plants. This wetland and associated spring are in excellent condition, but
		seep onto an old roadway causing substantial erosion and culvert failure downstream.
L-06-13	NF	Road berm and inadequate drainage has led to formation of a Palustrine Aquatic Bed
		wetland with a semipermanent flooding regime. Duckweed and typha are dominant
		species in their respective areas, with some sedge and mint around the margins.
		Drier edges are hawthorn, snowberry and rose. It appears that the roadside has been
		sprayed for thistle which has led to some in-wetland die-off, but the sediment and water
		loads are not in balance. Non-native grasses dominant in uplands. We rated this
		wetland non-functional because of excessive deposition and road effects.
L-06-14	PFC	Hart Spring, on private land (?) is functioning properly although there are many
		exotics in the vicinity and in the spring itself. The spring is a spikerush and
		bulrush dominated wetland, with some milkweed, mint and nettle, and foxtail
		barley, dock, and green needlegrass in the drier margins. Japanese and smooth
		brome are present along the edges, and crested wheat is abundant in the surrounding
		uplands.

SITE	CONDITION	COMMENTS (BLM SITES IN RED)
L-06-15	FAR/D	This excavated pond (Palustrine Aquatic Bed) appearsd to be a popular watering
		area for cattle, with substantial hoof disturbance along the edges. There is some
		spikerush near the water's edge but the dominant vegetation near the wetland is foxtail
		barley, suggesting that the water levels are drawn down considerably as summer
		progresses. There is some bulrush at the downstream end, but the overflow/seepage
		area is mostly greasewood and saltgrass, indicating high salinity levels in the water
		or soil. Upland areas, which are mostly wheatgrass, contain a lot of japanese brome
		and yellow sweetclover. The hoof action and breakdown of the shoreline earned this
		a downward trend FAR determination.
L-06-16	NF	This small bermed pond lacks any real wetland vegetation except for the ring of
		foxtail barley indicating soil moisture. It may be a new pond where spikerush has
		not yet established. There is considerable hoof action and shoreline destabilization
		from cattle. Uplands are dry, mostly needlegrass and silver sage, with some
		snowberry around the moist inlet area. The lack of wetland-dependent vegetation
		and the cattle damage contributed to the NF determination.
L-06-17	PFC	This is the upstream part of a series of wet draws and bermed ponds in the Bull
		Creek drainage in the foothills of the Little Rocky Mountains. Characteristic species
		include chokecherry, hawthorn, snowberry, rose, and licorice in th draws, with
		occasional stands of cattail in ponded areas. This site continues downstream
		into a wetter area with smartweed in standing water, spikerusha long the water's edge,
		and willows on the banks. The surrounding upland areas contain needlegrass with
		a lot of smooth brome, alfalfa, and crested wheat. In general these wetlands are
		functioning well, but we did note crop dusting just upwind of this site.
L-06-18	FAR/NA	This small depression has become a wetland because of a road berm restricting
		drainage. The center ring contains some spikerush, although it is being crowded
		out by common sunflower. Plains reedgrass constitutes about 10% of the cover.
		We gave this an FAR determination because the addition of a culvert under the
		road would end the drainage problem that created it.
L-06-19	FAR/D	This is a dammed pond/wetland fed by Blood Creek, lined with green ash and some
		cottonwood. Water appears to contain substantial sediment. Sprikerush and some
		bulrush grow along the water, with foxtail barley and snowberry in the riparian area.
		Smooth brome is common. Native grasses are mostly western wheatgrass and
		plains reedgrass. Flooding of trees and lack of young woody species were the
		determining factors in assigning a "downward" trend.

SITE	CONDITION	COMMENTS (BLM SITES IN RED)
L-06-20	FAR/UP	Dry Blood Reservoir has a fairly diverse wetland plant community including smartweed, bulrush, spikerush, some sedge, western wheatgrass, scattered cottonwood, foxtail-barley and inland saltgrass. Uplands are western wheatgrass and plains reedgrass with a heavy component of japanese brome, yellow sweetclover, yellow cress, mustards, and crested wheat. Russian knapweed was present. Despite the exotics, we thought the wetland was reasonably stable, although at risk because it depends on the dam.
L-06-21	NF	This impoundment on the south fork of Blood Reservoir is in a drier site, although the extreme downstream end has semi-permanent water with smartweed growing in it. Emergent vegetation is spikerush and some bulrush, with saltgrass on dry flats. Upland cover is sparse, and cattle walk into and through the water, causing severe pugging and hummocking, as well as vegetation removal in the uplands. The extent of cattle use and ensuing vegetation loss were the basis for the Not Functioning determination.
L-06-22	NF	The source of the water that has ponded near the end of this coulee on the east side of the Musselshell is unclear, and it is also unclear why there is no visible wetland vegetation. Downstream of this ponded area at the road embankment there is no surface water. The lack of vegetation and cattle-caused shore erosion were the reasons this was ranked as Not functioning.
L-06-23	FAR/D	A culvert on Blood Creek diverts water into this (excavated?) pond. Wetland plants are primarily spikerush and foxtail barley; banks are fairly well vegetated with western wheatgrass, prairie sandreed, and both smooth and Japanese brome. Coneflowers were abundant. Spotted knapweed was present, and there was evidence of grazing and trampling. Noxious weeds and trampling were the basis of the downward trend determination.
L-06-24	FAR/NA	This manmade pond was created by a dam, and has abundant cattail but little else in the way of riparian/wetland vegetation. There was ample evidence of deer and elk but no sign of cattle. Pond construction left a large bare dirt “ramp” with worsening rill and gully formation. Sides of the pond are steep and not well-vegetated. This pond/wetland is functioning but is at risk from erosion and the potential for dam failure.
L-06-25	NF	Small amounts of spikerush and foxtail barley ring this small reservoir, which appears to be a favored sheep shade source--a band of sheep with a guard llama were grouped under the cottonwoods and Russian olive. Water drawdown appears too great to maintain wetland vegetation through the summer. Upland vegetation mostly exotics and western wheatgrass, with knapweed also present. This is not functioning as a wetland.

SITE	CONDITION	COMMENTS (BLM SITES IN RED)
L-06-26	FAR/U	Although bermed, this wetland is in good condition, with thick spikerush and bulrush
		stands. Foxtail barely, curley dock and western wheatgrass form the drier margins.
		Aside from yellow sweetclover, exotics are not widespread and no noxious weeds were
		observed. This wetland appears to be enlarging, and while functioning at risk because
		of its dependence on the berm, its trend appears to be upward.
L-06-27	FAR/NA	Another wetland created by a road berm/culvert combination, this one has very thick
		stands of spikerish, bulrush, cattails and sedges, indicating season-long water. Foxtail
		barley is interspersed with dock. Wheatgrass and crested wheat in uplands. No signs
		of cattle using this wetland.
L-06-28	FAR/NA	Road-berm wetland with bulrush, spikerush, cattail and smartweed. Some
		marestail below surface and algal scum forming on surface. FAR because of road berm
L-06-29, 29b	FAR/UP	There are effectively two separate wetlands here, the Lacustrine fringe wetland around
		Drag Creek reservoir and the Palustrine aquatic bed wetland formed below the berm.
		The fringe wetland is mostly sprikerush and some bulrush; the aquatic bed wetland has
		bulrush (2 species), cattails (2 species), sprikerush, mint, foxtail barley, and western
		wheatgrass. There is some Japanese brome. No cattle or sheep were present, but there
		was a sheepherder's wagon, and signs of human recreational pressure (styrofoam,
		cigarette butts, firecrackers, campfire rings. Fish were present in the reservoir. These
		two wetlands were ranked as functioning at risk only because of risks associated with
		the berm and culverts.
L-06-30	FAR/D	This bermed stockpond is heavily used by cattle, and has excessive pugging, trampling
		and manure deposition. Arum-leave arrowhead is abundant around one end, but wetland
		vegetation elsewhere is limited to spikerush and foxtail barley. Japanese brome is
		common in the surrounding upland. Amphibians were present in this pond but not
		sampled. The grazing impacts led to a downward trend detrmination.
L-06-31	FAR/UP	This is another wetland created by a road/culvert combination. The wetland is a
		complex of aquatic bed ponds, heavily overgrown with cattails, bulrush and spikerush
		except for one small open area upstream where the water is deeper, and a ponded.
		area downstream of the road in a wooded draw. The plant community exhibits high
		vigor and is choking the waterway, further reducing drainage. We considered this
		wetland to be stable but functioning at risk because of the dense growth and the
		culvert/road system.

SITE	CONDITION	COMMENTS (BLM SITES IN RED)
L-06-32	FAR/D	Lacustrine fringe wetland around a reservoir with bulrush (2 species), spikerush (2
		species), foxtail barley. Shallower areas have abundant bladderwort. Uplands are
		prairie sandreed and mixed exotics with mustards, cress and saltbush. Pugging
		and hummocking are extensive, and the road crosses the berm, leading to
		sedimentation and the threat of structural collapse at some point. The trend
		appears to be downward, largely due to the cattle damage.
L-06-33	FAR/D	Jakes Reservoir. A Lacustrine fringe wetland with spikerush and barley but
		no bulrush, suggesting greater summer water drawdown than L-06-32. Uplands
		are similar. Widespread pugging and hummocking.
L-06-34	FAR/NA	Buffalo Wallow Reservoir (Lacustrine fringe) and associated downstream wetland.
		The upstream wetland has some bulrush but us mostly a spikerush/foxtail barley
		fringe. The downstream wetland has cattail, bulrush, sprikerush, some sedge,
		foxtail barley, and mustards. A supplement feeder and insect dust bag for cattle
		are very close to the shoreline, and there is evidence of moderate pugging and
		hummocking. The downstream wetland appears to have little cattle activity.
		Knapweed is widespread. This area was on the edge of exhibiting a downward trend,
		especially if cattle activity increases.
L-06-35	FAR/UP	A layer of algal scum on this pond indicates nutrification, probably resulting
		from extensive grazing also visible in pugging and hummocking. Knapweed is
		present. Bulrush and spikerush form the fringe, with foxtail barley ringing the
		wetland. Uplands are mostly sage and greasewood. The overflow wetland
		downstream of the berm is more stable, with sprikerush, some cattail, and
		bulrush. The algal layer and grazing damage in the upper wetland gives that a
		downward trend, but the lower wetland trend is upward.
L-06-36	PFC	This site has two small wetlands, one created by the road berm and one
		that may have been excavated or enlarged some time ago. Both have spikerush-
		foxtail barley vegetation, no pugging or hummocking, and no other disturbance.
		Both appear to have naturalized and to be stable, so we gave them a PFC
		determination.
L-06-37	FAR/U	Although this pond is manmade, and depends on a berm, it has ample
		vegetation (spikerush, bulrush, some cattail, foxtail barley), stable banks
		and healthy surrounding uplands, so while we gave it an FAR determination,
		we also assigned it an upward trend.

SITE	CONDITION	COMMENTS (BLM SITES IN RED)
L-06-38	FAR/UP	Dry Wolf Reservoir. This large reservoir is ringed by spikerush, with some
		bulrush in deeper, more permanently flooded areas, and a ring of foxtail
		barley. Uplands are moderately grazed, and vegetation is somewhat sparse,
		but pugging and hummocking are not severe. This site appears stable and
		with grazing management the trend will be upward.
L-06-39	PFC	This is an extensive slough at the head of a coulee with some bulrush and
		cattail in wetter areas, but mostly spikerush, foxtail barley, sloughgrass,
		smooth brome, dock and bluejoint. Cattle graze near edges but do not
		appear to be making extensive use of slough itself. No noxious weeds
		were observed, so we gave this a PFC determination.
L-06-40	FAR/U	Small roadside wetland with smartweed, spikerush and some sedges.
		Appears to have more use from deer and antelope than from cattle.
		Road berm is probably the dominant hydrologic influence, so we called
		it as functioning at risk but with an upward trend.
L-06-41	FAR/NA	Wetland formed by road berm restricting drainage. Algal scum on surface.
		Marestail just breaking surface in sections. Fringe is mostly spikerush. This
		is typical of the wetter wetlands in this vicinity. The road influence accounts
		for the FAR determination.
L-06-42	PFC	Small wetland with abundant arrowhead, hardstem bulrush, alkali bulrush,
		cattails and spikerush. No evidence of grazing, but hayfield immediately
		adjacent could be a source of sediment if plowed.
L-06-43	NF	Excavated pond on floodplain of Missouri near mouth of Woodhawk Creek.
		Small amounts of marestail and pondweed below the surface, but no fringe
		vegetation, suggesting that the pond is new. This site was visited late
		in the season and there was still standing water, so the explanation for
		the ansence of vegetation is not clear.

Appendix C. Macroinvertebrate Taxa Lists, Abundance and Plains MMI Calculations at Each Site

	Fish Species Total	Fish Species Native	Fish IBI	O/E	Macro-invert Taxa	MT MMI	O/E
Sacajawea River watershed							
Sacajawea River #1	5	5	68.58	66.67	25	**44.337**	**>80**
Sacajawea River #2	6	5	**70.40**	66.67	34	**37.778**	**70**
Sacajawea River X_FWP_2003dn1	7	4	58.46	53.33	na	na	na
Sacajawea River X_FWP_2003dn2	9	6	69.46	**80.00**	na	na	na
Sacajawea River #FWP_dn1	10	8	**74.47**	**106.67**	na	na	na
Sacajawea River #FWP_dn2	6	5	63.99	66.67	na	na	na
Sacajawea River #FWP_dn3	6	5	61.84	66.67	na	na	na
Blood Creek watershed	no fish	no fish	0.00	0.00	36	**57.1**	**>80**
Armells Creek watershed							
Red Mtn Spring* (E.F. Armells)	no fish	no fish	no fish	no fish	9	52.5	40
Armells Creek #1	4	4	52.86	53.33	22	**52.8**	71
Armells Creek #1 FWP 2004	8	7	52.36	**93.33**	na	na	na
Armells Creek #2 2005/2006	7	6	62.44	**70.59**	20	17.46	50
Armells Creek #2 FWP dn	8	7	**72.26**	**93.33**	na	na	na
Armells Creek #2 FWP dn	8	7	60.28	**93.33**	na	na	na
Armells Creek - DEQ1	na	na	na	na	24	26.6	55
Armells Creek - DEQ2	na	na	na	na	28	**46.7**	**>80**
Armells Creek - DEQ3	na	na	na	na	27	**38.8**	**>80**
Armells Creek - DEQ3 (replicate)	na	na	na	na	27	**48.7**	**>80**
Armells Creek - DEQ4	na	na	na	na	22	27.2	50
Two Calf Creek watershed							
Two Calf Creek #1	no fish	no fish	0.00	0.00	36	**61.98**	60
Two Calf Creek #1 FWP 2005	1	0	42.31	0.00	na	na	na
Two Calf Creek @ confluence w/ MO FWP 2006	7	5	**76.02**	66.67	na	na	na

Physical measures, water parameters and habitat descriptions for the lotic study sites. EPA HQI and BLM HQI=Habitat Quality Assessment Index, best score of 200 and 24, respectively. LUI=Livestock Use Index, %RP_SH= % Riparian Shading, % LWD=percent of transects out of 10 with Large Instream Woody Debris present, Cond=Conductivity (µS/cm), DO=dissolved oxygen in (mg/L).

Site	Date Sampled	Avg stream width (m)	Avg channel depth (cm)	Median channel depth (cm)	Reach Length (m)	EPA HQI	BLM HQI	LUI	% RP_SH	% LWD	% cobble	% fines in reach	pH	Cond	DO	Turb	Water Temp (C)
Judith Mtn Spring	6/26/2006	1.25	15.0	10.0	50.0	na	20	0	50	10	75	10	7.8	320	12	1	12.0
Armells Creek-1	6/26/2006	3.1	65.8	60.0	250	145	12.5	15	10	0	10.0	86.7	8.8	3380	4	80	26.8
Armells Creek-2	6/26/2006	3.5	74.0	68.0	300	150	14	10	10	0	20.0	95.0	8.9	3170	5	120	27.1
Two-Calf Creek	6/27/2006	1.7	25.1	26.0	250	122	12	18	0	0	24.0	66.7	8.1	2590	2.2	65	17.5
Blood Creek	6/28/2006	25.0	101.7	55.0	150	120	15	2	0	0	5.0	80.0	8.8	2320	2.5	220	21.4
Sacajawea -1	6/27/2006	3.1	34.3	30.0	300	162	17	0	0	0	40.0	8.3	8.8	2950	7	4	30.5
Sacajawea -2	6/27/2006	2.9	28.9	25.0	300	159	17	5	0	0	20.0	61.7	8.5	2480	3	10	29.6

Fish records from MTNHP and FWP surveys. Numbers indicate individuals captured

	Sacajawea #1 NHP 2006	Sacajawea #2 NHP2006	Sacajawea Xt1 2003	Sacajaewa Xt2 2003	Sacajawea_ dn1	Sacajawea_dn2	Sacajawea_ dn3	Armells Cr. #1 NHP 2006	Armells Cr. #1 2004 FWP	Armells Cr.#2 Dn NHP 2006	Armells Cr. #2 Dn 2004	Armells Cr.#2 Dn 7/27/1999	Two-Calf Cr. 2006	Two-Calf Cr.FWP	Two-Calf Cr.Con
Black Bullhead	0	2	6	3	0	0	0	0	0	0	0	0	0	0	0
Common Carp	0	0	716	314	1	384	4	0	1	773	0	128	0	2	67
Green Sunfish	0	0	2	3	3	0	0	0	0	0	0	0	0	0	0
Spottail Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Brassy Minnow	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brook Stickleback	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Channel Catfish	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Flathead Chub	0	0	0	342	3	0	0	0	0	50	109	40	0	0	30
Fathead Minnow	227	187	305	94	138	4	74	135	301	9	9	6	0	0	0
Longnose Dace	0	0	0	0	9	0	1	0	1	0	4	0	0	0	0
Lake Chub	271	326	162	117	60	148	86	5	12	0	5	0	0	0	0
Plains Minnow	0	8	787	500	265	231	504	0	1	5	15	20	0	0	4
River Carpsucker	0	0	0	0	24	0	0	0	0	447	0	3	0	0	115
Sand Shiner	67	13	5	16	153	3	36	25	5	72	5	0	0	0	0
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Longnose Sucker	0	0	0	0	0	0	0	0	0	4	0	2	0	0	0
White Sucker	0	24	0	43	68	0	0	18	5	0	0	22	0	0	3
Western Silvery Minnow	0	0	0	0	0	0	0	0	5	0	348	31	0	0	4
Total Individuals	**676**	**560**	**1983**	**1432**	**724**	**772**	**705**	**183**	**331**	**1360**	**497**	**252**	**0**	**2**	**224**
Total # species	**5**	**6**	**7**	**9**	**10**	**6**	**6**	**4**	**8**	**7**	**8**	**8**	**0**	**1**	**7**
Native Species	5	5	4	6	8	5	5	4	7	6	8	7	0	0	5
Native Fish Families	2	2	1	2	2	2	1	2	2	2	2	2	0	0	2

Bird, Herptofauna and Dragonfly/Damselfly Species Observations for upland prairie lentic sites of the BLM Watershed Assessment. SS= BLM Sensitive Species

Common Name	Scientific Name	MT SOC/ PSOC	BLM (SS)	Upper Buffalo Wallow Res.	Lower Buffalo Wallow Res.	Jakes Res.	Dry Fork Blood Res.	South Fork Blood Res.	No Name- BLM Res.	Crooked Creek Res.	Blood Creek Pool
Birds											
American Avocet	*Recurvirostra americana*					X					
American Coot	*Fulica americana*							X			
American Widgeon	*Anas americana*			X			X		X	X	X
Blue-winged Teal	*Anas discors*								X	X	X
Brewer's Blackbird	*Euphagus cyanocephalus*			X	X	X	X	X	X		
Brewer's Sparrow	*Spizella breweri*	SOC	X					X	X		
Brown-headed Cowbird	*Molothrus ater*							X	X	X	X
Common Nighthawk	*Chordeiles minor*						X				
Eared Grebe	*Podiceps nigricollis*								X	X	X
Gadwall	*Anas strepera*					X	X		X		
Golden Eagle	*Aquila chrysaetos*							X	X		
Great Blue Heron	*Ardea herodias*					X					
Horned Lark	*Eremophila alpestris*					X					
Killdeer	*Charadrius vociferus*					X	X	X	X		X
Lark Bunting	*Calamospiza melanocorys*	SOC					X				
Long-billed Curlew	*Numenius americanus*	SOC	X			X					
Lesser Scaup	*Aythya affinis*			X			X	X			
Mallard	*Anas platyrhynchos*						X		X	X	X
Mourning Dove	*Zenaida macroura*			X		X			X		X
Pied-billed Grebe	*Podilymbus podiceps*			X							
Red-winged Blackbird	*Agelaius phoeniceus*				X	X	X	X			X
Ring-billed Gull	*Larus delawarensis*			X		X			X		
Rudy Duck	*Oxyura jamaicensis*							X			
Upland Sandpiper	*Bartramia longicauda*						X	X			
Vesper Sparrow	*Pooecetes gramineus*					X			X		

Common Name	Scientific Name	MT SOC/ PSOC	BLM (SS)	Upper Buffalo Wallow Res.	Lower Buffalo Wallow Res.	Jakes Res.	Dry Fork Blood Res.	South Fork Blood Res.	No Name-BLM Res.	Crooked Creek Res.	Blood Creek Pool
Western Meadowlark	*Sturnella neglecta*			X	X		X		X		
Willet	*Tringa semipalmata*			X				X	X	X	X
Wilson's Phalarope	*Phalaropus tricolor*					X		X	X		
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*							X			
				8	3	12	11	13	16	6	9
Amphibians/Reptiles											
Boreal Chorus Frog	*Pseudacris maculata*			X	X						
Plains Garter Snake	*Thamnophis radix*							X			X
Tiger Salamander	*Ambystoma tigrinum*					X	X	X			X
Woodhouses' Toad	*Bufo woodhousii*				X						X
Plains Leopard Frog	*Rana pipens*							X			X
Dragonflies											
Common Green Darner	*Anax junius*			X	X	X	X	X	X	X	X
Paddle-Tailed Darner	*Aeshna palmata*									X	X
Common Whitetail	*Libellula lydia*	PSOC		X	X	X		X	X	X	X
Dot-tailed Whiteface	*Leucorrhinia intacta*						X				
Eight-spotted Skimmer	*Libellula forensis*	PSOC		X	X	X	X	X	X	X	X
Twelve-spotted Skimmer	*Libellula pulchella*						X	X	X		X
Variagated Meadowhawk	*Sympetrium corruptum*			X	X	X	X	X	X	X	X
Damselflies											
Taiga Bluet	*Coenagrion resolutum*			X							X
Northern Bluet	*Enallagma cyathigerum*						X	X			
Familiar Bluet	*Enallagma civile*			X	X	X	X	X	X	X	X
Eastern Forktail	*Ischnura verticalis*			X	X						X
Spotted Spreadwing	*Lestes congener*			X				X			X
Common Spreadwing	*Lestes disjunctus*						X	X	X		
				9	8	6	9	12	7	6	13
Total Incidental Species				17	11	18	20	25	23	12	22